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(10) Stuart G. Hibben, John Kourilo M. Ness

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This is the sixth collection of abstracts of recent Soviet articles on generation and detection of internal waves. It is based on items listed in the sixth Bibliography of Soviet Material on Internal Waves, published May 7, 1976, and covering material received from November 1975 through April 1976.

The abstracts are divided into internal effects and surface effects, comprising active and passive measurement of wave states. An author index is appended.

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INTRODUCTION

This is the sixth collection of abstracts of recent Soviet articles on generation and detection of internal waves. It is based on items listed in the sixth Bibliography of Soviet Material on Internal Waves, published May 7, 1976, and covering material received from November 1975 through April 1976.

The abstracts are divided into internal effects and surface effects, comprising active and passive measurement of wave states. An author index is appended.

TABLE OF CONTENTS

1. Internal Effects

Andryushchenko, A. A., and V. I. Belyayev. Optimizing station deployment of a network for simultaneous measurement of several statistically related oceanographic fields. FAiO, no. 10, 1975, 1047-1054.

Questions are discussed on the use of supplementary information in order to reconstruct fields of oceanographic elements at a given level. Space correlation and cross-correlation functions of temperature and salinity fields in the Black Sea are taken as an example, in which the authors apply an optimal matching algorithm to evaluate errors in field reconstruction. The results are cited as useful for planning measurements of oceanographic fields.

Babiy, M. V. Propagation of long waves in a multi-layered rotating fluid above a rough bottom. Morskiye gidrofizicheskiye issledovaniya, no. 1, 1975, 70-77. (RZhGeofiz, 2/76, #2V96). (Translation)

An equation describing free oscillations in an n-layered liquid with arbitrary layer depths rotating above a rough bottom is developed in a linear formulation, using the theory of long waves. The effect of layer slope is compensated for by a gradient flow. It is shown that internal waves are not generated by surface waves if depths of layers change proportionally with change in overall depth.

Babiy, M. V., and L. V. Cherkesov. Generation of internal waves by an underwater obstacle. FAiO, no. 9, 1975, 971-975.

Generation of internal waves in a two-layered sea by periodic surface waves propagating over an underwater discontinuity, e.g. a ridge or trough, is analyzed. The problem is solved by an analytical-numerical method in the framework of the linear theory of long waves. The numerical calculations are made for the case when the amplitudes of surface and internal waves propagating from a deep-water region (region 1 in Fig. 1) are unity and zero, respectively, while the depth of the lower layer in the transition regions (regions 2 and 4 in Fig. 1) is a linear function of x. The bottom profiles considered are shown in Fig. 1. Motion in each region is described by the equation system

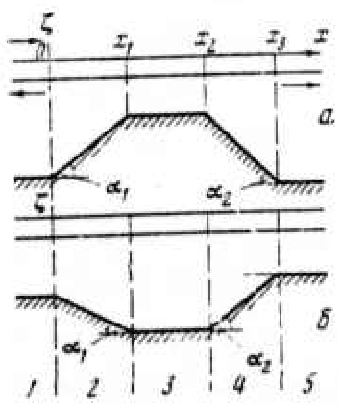


Fig. 1. Schematic of bottom profiles.

$$
\begin{gathered}
u_t - 2\omega v = -g\zeta_x, \qquad v_t + 2\omega u = 0, \\
\bar{u}_t - 2\omega\bar{v} = -g\frac{\rho}{\bar{\rho}}\zeta_x - g\varepsilon\bar{\zeta}_x, \qquad \bar{v}_t + 2\omega\bar{u} = 0, \\
(hu)_x = \bar{\zeta}_t - \zeta_t, \qquad (\bar{h}\bar{u})_x = -\bar{\zeta}_t,
\end{gathered}
\tag{1}
$$

where $\epsilon = \Delta\rho/\bar{\rho}$, and t, x indicate corresponding derivatives. Assuming a periodical motion eqs. (1) reduce to a fourth-order differential equation for $\xi(x)$. Furthermore, if it is assumed that amplitudes A_1, B_1 are given, and taking into account that

$$
\begin{gathered}
u = -\frac{i\sigma g}{\sigma^2 - 4\omega^2}\frac{d\zeta}{dx}, \qquad \bar{\zeta} = \zeta + \frac{gh}{\sigma^2 - 4\omega^2}\frac{d^2\zeta}{dx^2}, \\
\bar{u} = u - \varepsilon\frac{i\sigma g^2 h}{(\sigma^2 - 4\omega^2)^2}\frac{d^3\zeta}{dx^3},
\end{gathered}
\tag{2}
$$

and when con.inuity conditions are satisfied for ξ, $\bar{\xi}$, u, $\bar{u}$ at $x = 0$, $x = x_1$, $x = x_2$, and $x = x_3$, then sixteen algebraic equations for amplitudes of surface and internal waves are obtained.

The results of numerical calculations are presented in Figs. 2-4, and Tables 1 and 2. Calculations of the effect of obstacle width (Figs. 2, 3) and height (Fig. 4) on the amplitudes of internal waves, $B_2, \ldots, B_5$ are m^de for: $5 \times 10^2 < H_{1,5} < 6 \times 10^3$; $1 \times 10^2 < H_3 < 6 \times 10^3$, $20 < h < 5 \times 10^2$; $5 \times 10^{-5} < \delta < 10^{-3}$; $10^{-4} < \epsilon < 5 \times 10^{-3}$; and $10^1 > \alpha_{1,2} < 89^\circ 30'$. Calculations show that

there exists a spectrum of obstacle width values, $d_n = d_o + n\lambda$ (λ is wavelength of internal waves) for which B_5 (d) has a maximum; here parameter d_o depends on α_1, and α_2, increasing with them up to $\lambda/2$. There also exists a spectrum of d values, $d_n = d_o + (n + \frac{1}{2})\lambda$ for which the function $\bar{B}_5$ (d) has minima. The minima are zeros for $H_1 = H_5$ and greater than zero for $H_1 \neq H_5$. It is found that functions $\bar{B}_2$ (d) and $\bar{B}_5$ (d) are similar both for the case of ridge and trough.

The analysis reveals a strong dependence of the amplitude of internal waves on the steepness of obstacle slopes. As far as reflection of internal waves is concerned, this can be neglected when the thickness of the upper layer is much smaller than the obstacle depth.

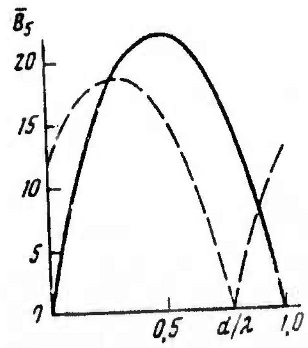


Figure 2. Dependence of amplitude of internal waves on obstacle width, $d = x_2 - x_1$ for $\alpha_1 = \alpha_2 = 89^\circ 5'$ (solid line), and $\alpha_1 = \alpha_2 = 2^\circ$ (dashed line). $H_1 = H_5 = 2$ km; $H_3 = 0.5$ km; $h = 0.2$ km; $\delta = 10^{-4}$ $sec.^{-1}$; $\epsilon = 2 \times 10^{-3}$.

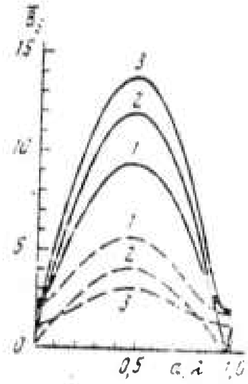


Fig. 3. Dependence of amplitude of internal waves on obstacle width for ridge (solid lines), and trough (dashed lines) for: $H_1 > H_5$ (1); $H_1 = H_5$ (2); and $H_1 > H_5$ (3).

$\delta = 1.4 \times 10^{-4}$ sec^{-1}; $\epsilon = 10^{-3}$; $\alpha_{1,2} = 45^{\circ}$; $h = 0.5$ km; $H_1 = 4$ km; $H_5 = 3, 4, 5$ km (curves 1, 2, 3); $H_3 = 2, 6$ km, for ridge and trough, respectively.

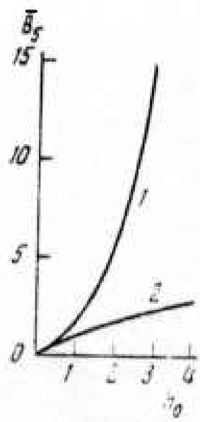


Fig. 4. Dependence of amplitude of internal waves on obstacle height, $h_o = / H_1 - H_3 /$ for ridge (1), and trough (2).

$\delta = 10^{-4}$ sec; $h = 250$ m; $\epsilon = 2 \times 10^{-3}$; $H_{1,5} = 4$ km.

Belyayev, V. S., A. N. Gezentsvey, I. D. Lozovotskiy, and R. V. Ozmidov. Some features of small-scale fluctuations of electrical conductivity in sub-Antartic and Antarctic water structures. Okeanologiya, no. 4, 1975, 605-610.

Measurements of mean conductivity $\bar{\delta}$ (in the 0-1 Hz range), pulsed conductivity δ (1-250 Hz), and depth H were carried out along a portion of the Tasmania-Antarctica profile (Fig. 1) in January-February 1974 during the 11th curise of the R/V Dmitriy Mendeleyev. During the measurement period the profile crosses the frontal zone of the Antarctic convergence at about 54°S.

Typical $\bar{T}(z)$ curves measured in sub-Antarctic (stations 811-813), and in Antarctic (stations 821-823) waters are shown in Fig. 2. Spectral density for fluctuations of electrical conductivity, $E_1^{(\delta)}(k)$ are shown in Figs. 3 and 4.

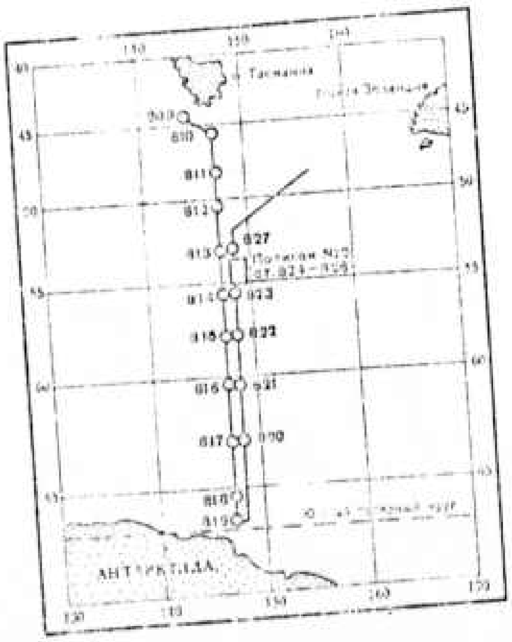


Fig. 1. Location of measurement stations on Tasmania-Antarctica profiles.

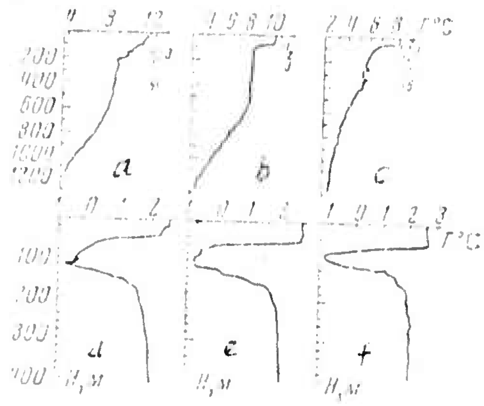


Fig. 2. Vertical temperature profiles, $\overline{T}(z)$ measured on Tasmania-Antarctica profile.

a- station 811; b- 812; c- 813; d- 821, e-822; f-823.

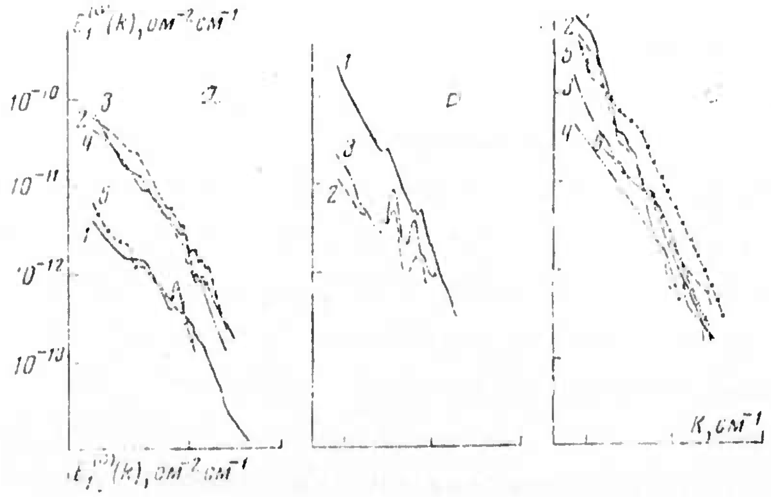


Fig. 3. Spectral density for δ' measured in sub-Antarctic waters (stations 811-813). Curve numbers- see designations in Fig. 2, a-c.

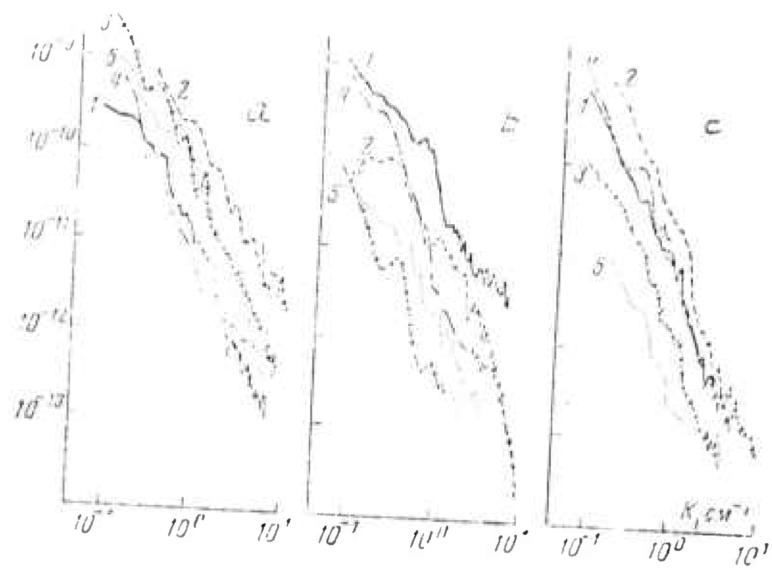


Fig. 4. Spectral density for δ' measured in Antarctic waters.

a- measured in thermocline; b- intermediate cold layer; c-intermediate quasihomogeneous layer.

In sub-Antarctic waters, $E_1^{(\delta)}(k)$ curves in the quasi-homogeneous layer have a relatively low level and can be approximated by a (-5/3) power law over a wide range of k; in the high-gradient layer $E_1^{(\delta)}(k)$ curves can be approximated by a (-1) power law at $k \leq 1\ cm^{-1}$, while their slopes increase significantly at $k > 1\ cm^{-1}$. However, they can sometimes be approximated by a (-2.5) power law within the entire range of k (see Fig. 3, c- curve 1). It is explained that in the high-gradient layer, flow velocity fluctuations are suppressed to such a degree that the energy dissipation rate can drop to $10^{-6}\ cm^2\ sec^{-3}$. The internal

turbulence scale in such a case increases and the dissipation range can shift toward the k range considered.

In Antarctic waters, $E_1^{(\delta)}(k)$ curves in the thermocline have their highest levels and steepest slopes at $k = 10^{-1} - 10^{0}\ cm^{-1}$. In the intermediate quasihomogeneous layer they can be approximated by a (-5/3) power law over a fairly wide k range (Fig. 4, c). This fact is explained by the presence of a developed turbulence owing to convective mixing. In the intermediate cold layer $E_1^{(\delta)}(k)$ curves have diverse shapes and slopes. This layer is characterized by a pronounced microstructure in its density field (Fig. 2, d).

The authors note that the present results suggest a direct connection between parameters of small-scale fluctuations of electric conductivity and local hydrological conditions. The latter are, on the other hand, determined by characteristics of large-scale hydrophysical fields.

Belyayev, V. S., T. D. Lozovatskiy, and R. V. Ozmidov. Investigation of relation between characteristics of fluctuations of electric conductivity and vertical temperature profiles in the ocean. FAiO, no. 10, 1975, 1078-1083.

Measurements are discussed which were made at station 821 (60°30' S; 147°E) of the Tasmania-Antarctica meridional profile during the 11th cruise of the R/V Dmitriy Mendeleyev.

An analysis of measurements shows that high-intensity fluctuations of electric conductivity δ' are observed over depth intervals with large temperature gradient, $\Delta \bar{T} / \Delta z$. Spectral densities for δ' which correspond to characteristic portions of a $\bar{T}(z)$ curve are shown in Fig. 1. It is pointed out that the shapes of $E_1^{(\delta)}(k)$ curves

are closely related to the microstructure of T (z).

A quantitative estimate of the relation between δ' and $\overline{T}$ fields is made by calculating correlations between vertical profiles of the logarithm of structural function for δ' and $\Delta\overline{T} / \Delta z$, $R_D^{(k)}(z)$, and between running variance for δ' and $\Delta\overline{T} / \Delta z$, $R_S^{(k)}(z)$. (In Fig. 2 $R_{(D)}^{(8)}(z)$ and $R_S^{(k)}(z)$ attain the highest levels; corresponding series $\Delta T_i^{(8)} / \Delta z$ are constructed with a step of 5.6 m. Thus fluctuations in electric conductivity are best correlated with vertical inhomogeneities in the temperature field whose scale is $l_k / 2 = 5.6$ m. In addition it is found (Fig. 3) that at small temperature gradients (0-0.006 deg/m) there occurs a δ' with structural function $D^{(\delta)}(r_3) = 10^{-11}$ ohm^{-2} cm^{-2} ($r_3 = 8.8$ cm). As temperature gradient increases, the probability for δ' with $D^{(\delta)}(r_3) < 10^{-11}$ ohm^{-2} cm^{-2} sharply decreases, and values of the structural function reach 10^{-9} ohm^{-2} cm^{-2}.

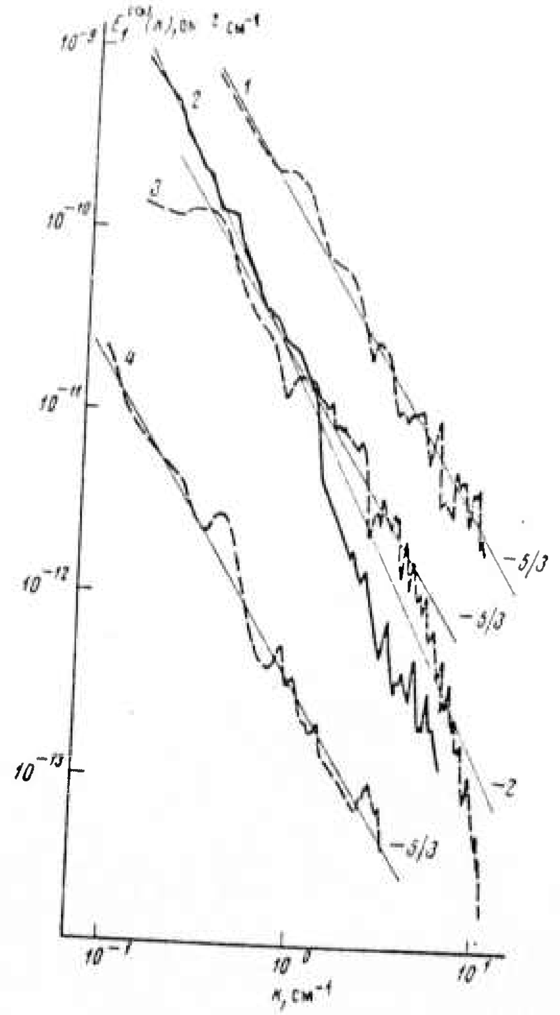


Fig. 1. Spectral densities for δ' observed over various depth intervals: 1- 60- 74m; 2- 81- 100m; 3- 139- 158m; 4- 230- 247m.

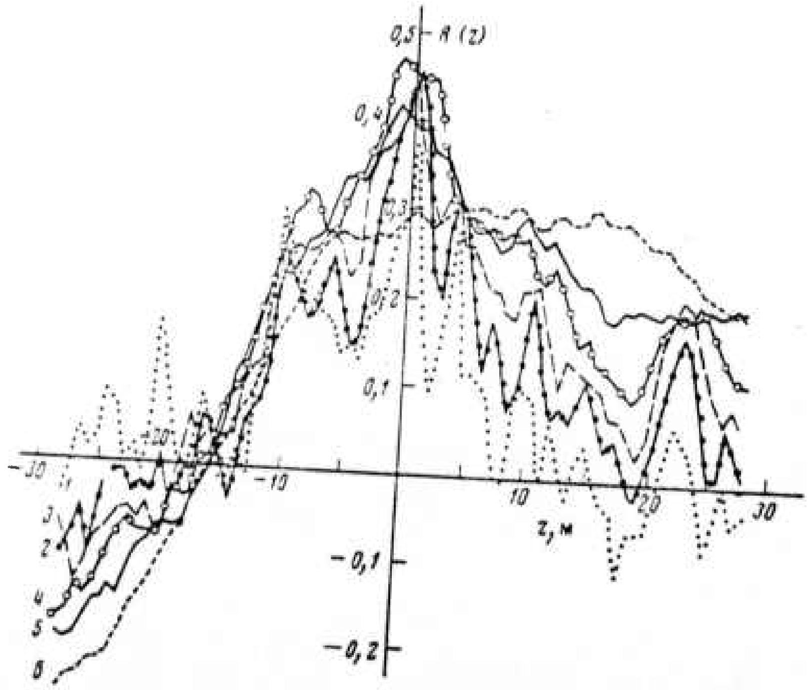


Fig. 2. Normalized correlations $R_D^{(k)}(z)$ (a), and $R_S^{(k)}(z)$ (b): 1 - k = 1; 2 - k = 2; 3 - k = 4; 4 - k = 8; 5 - k = 16; 6 - k = 32.

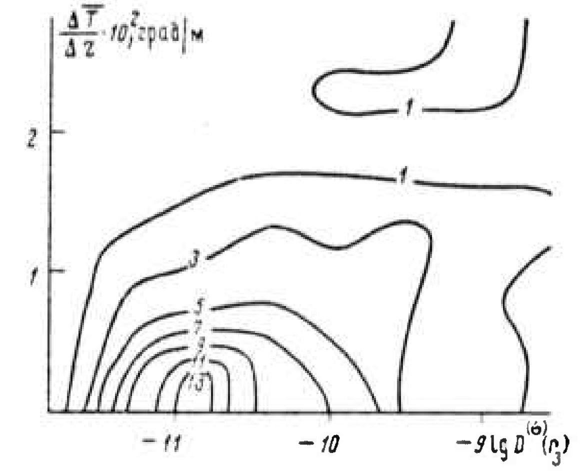


Fig. 3. Two-dimensional distribution of probability (%) of falling into a 0.35 x 0.003 deg/m window for simultaneous values of series $\lg D^{(\delta)}(r_3)$ and $\Delta \overline{T}^{(\delta)} / \Delta z$ (best correlated series).

Benilov, A. Yu., I. D. Lozovatskiy, and A. L. Sukhov. Problem of turbulence spectrum in a shear flow. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 101-104. (RZhGeofiz, 11/75, #11V_0). (Translation).

A spectral model of turbulence in quasihomogeneous layers of the ocean and atmosphere is considered. According to this model, a change in width of the inertial interval in the velocity spectrum is proportional to the change in local value of the Reynolds number.

Bolonov, N. I., I. L. Povkh, T. T. Sobolevskaya, and A. M. Kharenko. Analysis of stationary turbulence by digital methods. Donetskiy universitet. Donetsk, 1975, 12 p. (RZhMekh, 1/76, #1B117DEP). (Translation)

A version of the method of analysis of stationary turbulence is proposed. Recommendations on theoretical and practical aspects of the method are given.

Borisenko, Yu. D., A. G. Voronovich, A. I. Leonov, and Yu. Z. Miropol'skiy. Theory of nonstationary weak nonlinear internal waves in a stratified fluid. FAiO, no. 3, 1976, 293-301.

Spatial and temporal evolution of packets of internal waves in a stratified fluid at rest are investigated. Propagation of two-dimensional internal waves is described in the Boussinesque approximation by:

$$\rho_0(z)\left[\partial\Delta\Psi/\partial t+\mathcal{J}(\Delta\Psi,\ \Psi)\right]=g\partial\rho/\partial x, \tag{1}$$

$$\partial\rho/\partial t+\mathcal{J}(\rho,\ \Psi)=0 \tag{2}$$

where ψ (x, z, t) is flow function, Δ is the Laplacian, J is Jacobian, and ρ_0 (z) is undisturbed density. Boundary conditions for Eqs. (1), (2) are

$$\partial\Psi/\partial x\,|_{z=0}=\partial\Psi/\partial x\,|_{z=-H}=0. \tag{3}$$

An approximate solution of Eqs. (1) for the case of small amplitudes is found by the method of multiscale expansions. A closed system of equations in an approximation of linear ray optics is obtained which defines the parameters of internal waves. The equation for flow function has the form

$$\Psi^{\varepsilon}(\xi, \tau, z, \Theta) = \varepsilon a \varphi_1 \cos(\Theta + \beta) + \varepsilon^2 \{ C(\xi, \tau, z) + a^2 \varphi_2 \cos[2(\Theta + \beta)] \} + O(\varepsilon^2) \quad (4)$$

The nonlinear dispersion relation is

$$\Omega(k, a) = \omega(k) - \varepsilon^2 I(k) a^2, \quad (5)$$

where Ω is total frequency, and ω is frequency in a linear approximation. The closed system of equations obtained is very complex, and it is integrated by the method of characteristics for the case of ω= const, k = const. The solution is analyzed for the case when $\mu(z) = g \rho_o^{-1} (d\rho o/dz)$ is a constant. This analysis shows that at $k < k_* = n \pi H^{-1} (\sqrt[3]{4} - 1)^{\frac{1}{2}} \cong 2.4\, nH^{-1}$ ($\omega < \omega_* \cong 0.6 \mu^{\frac{1}{2}}$), internal waves are unstable with respect to longitudinal disturbances, while at $k > k_*$ they are stable. At $k = k_*$ internal waves are in resonance with the mean flow generated by them. In the neighborhood of a resonant point, this approximation is not valid. However, in the vicinity of $k \cong k_*$, even in the case of relatively small internal wave amplitudes, mean flow can be very intense.

The authors note that the transition from nonstationary to stationary theory of weakly nonlinear internal waves is nontrivial. Nevertheless an approximate description of periodic waves propagating within a very long wave packet can be obtained in the framework

of stationary theory. However, wave-induced mean flow cannot be described correctly. Furthermore, the stability of periodic weakly nonlinear internal waves depends on wave-induced mean flow and on stratification. Long internal waves are an exception, since their stability depends on stratification only at μ = const. The results also indicate that intense wave-induced flow is possible; this has a unique circular structure and can perform horizontal and vertical mixing of water masses. In the same way spatial **distortions** in density field originate, which may be responsible for the thermohaline microstructure of the ocean.

Brekhovskikh, L. M., V. V. Goncharov, and V. M. Kurtepov. <u>One-dimensional problems in the nonlinear theory of waves in the ocean</u>. Okeanologiya, no. 6, 1975, 949-954.

This article is a continuation of previous reports by the authors on nonlinear interaction of wave fields in the ocean. Simulation of the interaction of a continuous wave spectrum by a resonance triad is shown to be valid only within a short initial time interval, under real ocean conditions. Evidence is cited for the broadening of the initial narrow wave spectra, owing to the interaction of many resource and "near resonance" triads. The authors also examine the process resulting in equilibrium spectra for waves generated by sources in the long-wave region. They conclude that modeling the interaction of ocean waves requires the inclusion of a large number of waves, even for the case of quasimonochromatic wave packets.

Chernysheva, Ye. S. Investigating parameters of internal waves by numerically solving hydrodynamic equations for a two-layered liquid. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 28-31. (RZhGeofiz, 11/75, #11V119). (Translation)

A one-dimensional problem of internal waves in a two-layered liquid is solved numerically. Effects of depth, stratification, and visosity on the internal wave parameters are analyzed.

Davidan, I. N., A. K. Bochkarev, and Yu. A. Trapeznikov. Performance tests of improved GM-16M and GM-32 wave recorders. IN: Trudy Gosudarstvennogo okeanograficheskogo instituta, no. 117, 1973, 104-112. (RZhGeofiz, 2/74, #2V23). (Translation)

A description is given of improved models of GM-16M and GM-32M wave recorders, as well as of performance tests during the 8th cruise of the weather ship "Passat". Sources of large errors in measurements by standard GM-32 wave recorder are identified, and methods for their elimination are suggested. It is demonstrated that routine measurements of wind waves aboard a research vessel of large displacement are possible in principle.

Dotsenko, S. V., M. G. Poplavskaya, and G. A. Tolkachenko. Measurement of two-dimensional random fields. Morskiye gidrofizicheskiye issledovaniya, no. 2, 1975, 45-59. (RZhGeofiz, 2/76, #2V61). (Translation)

The space-time structure of two-dimensional random scalar hydrophysical fields is described, using the following parameters: coefficient of anisotropy; angle of the ellipse of spatial correlations; magnitude and angle of field transfer rate relative to fixed measuring instruments; and radii of space-time correlations. It is assumed that a physical field has elliptical anisotropy, and that it is not subject to the hypothesis of "frozen" turbulence. A method is proposed for the calculation of parameters of such a field from measurements of any scalar characteristic at three points lying in a given horizontal plane.

Dotsenko, S. V., M. G. Poplavskaya, and G. A. Tolkachenko. Calculating parameters of space-time variability of a physical field from experimental data. Morskiye gidrofizicheskiye issledovaniya, no. 2, 1975, 60-67. (RZhGeofiz, 2/76, #2V62). (Translation)

A method is proposed for calculating anisotropy, radii of spatial and temporal correlations, and transfer rate of a physical field, based on experimental data. Calculations are made for a surface-wave field using measurements at three points. It is concluded that, in the case considered, temporal evolution of the field should be accounted for in the interpretation of the results.

Grishin, G. A., and V. V. Yefimov. Effect of viscosity on internal waves generated by disturbances in atmospheric pressure. FAiO, no. 2, 1976, 176-188.

A two-dimensional approach is used to analyze the problem of wave excitation in a viscous fluid, generated in the density jump layer by a varying pressure on the sea surface. A coefficient of turbulent viscosity is introduced to account for turbulent motion. The problem is solved by the method of matched asymptotic expansions.

Assuming the existence of free oscillations, the authors determine several terms in the expansion of the current functions, in order to arrive at the amplitude of induced oscillations at the exciting frequency. In the framework of the viscous model the authors also study other effects in the jump layer, including wave tangential stress and stationary wave velocity.

Gushchin, O. A. Nature of turbulent mixing in a stratified ocean. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 44-46. (RZhGeofiz, 12/75, #12V53). (Translation)

An analysis is made of the relationship between exchange coefficient and the main parameters of motion. The exchange coefficient is found by solving the equation of turbulent energy balance. The behavior of the exchange coefficient is analyzed for given profiles of zonal components of velocity vector and density.

Ivanenko, G. V. Spectrum of hydrodynamic turbulence. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 105-108. (RZhMekh, 10/75, #10B977). (Translation)

A hypothesis on the form o a spatial-temporal turbulence spectrum and its relationship with the Green function is advanced. It is shown that spatial-temporal viscosity plays an essential role in the similarity region.

Kalatskiy, V. I. Numerical solution of a system of equations for turbulent motion of the upper ocean layer. IN: Trudy Gidrometeorologicheskogo nauchno- issledovatel'skogo tsentra SSR, no. 119, 1975, 61-69. (RZhGeofiz, 11/75, #11V59). (Translation)

The nonstationary problem of calculation of temperature distribution in the active ocean layer during a warmup period is considered. A numerical method for solution of the equation system for a turbulent boundary layer in the ocean is proposed. The system consists of equations of motion, of thermal conductivity, of balance of turbulent energy, and of Kolmogorov's relations, closing the system. Two numerical schemes for solution of the equation for balance of turbulent energy are proposed, one for near-surface, another for deeper layers. The calculations show that the set of equations considered allows one to deduce the main characteristics of the thermal structure of the active ocean layer.

Klimok, V. I., and V. A. Sukhorukov. The problem of vertical turbulent diffusion in the ocean. IN: Chislenyye metody rascheta okeanicheskikh techeniy. Novosibirsk, 1974, 153-162. (RZhMekh, 7/75, #7B603). (Translation)

A model study is made of vertical turbulent transfer of momentum and heat in an ocean basin with a depth of 200 m. The equation of turbulent energy transfer, b , dissipation function, D, as well as expressions relating b and D to eddy viscosity coefficient K and turbulence scale, are used for closing the initial equation system. On the surface of the ocean the flow velocity u, temperature T, and vertical fluxes of b and D are defined; at the ocean bottom u , b , and D are zero and T has a fixed value. The initial system of equations is solved numerically by computer, using the "natural filtering" approximation with respect to the time coordinate, and the balance method approximation with respect to the space coordinate. Calculations are made using even and uneven spatial grids, various iteration steps along the time coordinate, various relationships between boundary values. coefficient and thermal conductivity, and various boundary values. Results of calculations for vertical profiles of u , T, K, b , and D are plotted.

Korchashkin, N. N., and I. D. Lozovatskiy. Wave disturbances of the temperature field in a stratified fluid. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 12-16. (RZhGeofiz, 11/75, #11V79) (Translation)

An equation is derived which describes the disturbances in temperature field induced by internal waves. The equation is analyzed for two representative types of vertical distribution of the Vaisalaa number, N (z), i.e. a two-layered model, and an exponential distribution which is characteristic of equatorial regions of the ocean.

Kochergin, V. P., V. I. Klimok, and V. A. Sukhorukov. Modeling of vertical turbulence in the North Atlantic. IN: Chislenyye metody rascheta okeanicheskikh techeniy. Novosibirsk, 1974, 163-168. (RZhMekh, 7/75, #7B604). (Translation)

Circulation in the North Atlantic from 12.5° N to 52.5° N is analyzed numerically allowing for baroclinic and bottom relief effects. Equations for weakly anisotropic turbulence are included in the initial equation system in order to determine coefficient of vertical turbulence. The analysis is restricted to the uppermost 300m layer. Two cases are considered regarding turbulent flows at the surface of the ocean: zero flows, and flows which are non-zero but constant over the entire ocean surface. In the former case an initially defined turbulent region disappers completely. In the latter case existence of a turbulence source at the ocean surface leads to the formation of a 40m turbulence layer.

Kozhelupova, N. G. Spatial characteristics of an internal wave field in the ocean. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 21-24. (RZhGeofiz, 11/75, #11V117). (Translation)

A description is given of a method for calculating two-dimensional correlation functions and two-dimensional spectra of internal waves in the ocean. Calculations were made using one-dimensional auto-correlation functions for fluctuations of temperature, measured in a test area along several tacks by a thermistor chain. Results of numerical calculation of two-dimensional characteristics of the internal wave field are given.

Kozhelupova, N. G., Yu. Z. Miropol'skiy, and B. N. Filyushkin. Vertical variability of the spatial structure of an internal wave field in the ocean. Okeanologiya, no. 6, 1975, 962-965.

Two-dimensional correlation functions for fluctuations in temperature field in the active oceanic layer (Fig. 1) are calculated. The measurements used were made in a mid-latitude test area during the second cruise of the R/V Dmitriy Mendeleyev in 1969. Observations were made at ten depths within a 20-100 m layer by towing a thermistor chain along four tacks for an overall length of 18 miles. The results of calculations are shown in Figs. 2 and 3.

The results show that temperature fluctuation fields are isotropic over small distances (200-300 m), and anisotropic over large distances at all levels except for that at 35 m. Also, the direction of the maximum correlation radius varies with depth in a manner similar to the variation of the direction of the vector of mean flow. The entire correlation pattern rotates clockwise by $\pi/2$ as depth changes from 35 to 86m.

It is suggested that anisotropy and depth-variation of anisotropy in a temperature variation field are associated with a changing pattern of the mean flow. The present results are explained in the light of Bretherton's finding on propagation of groups of internal waves in a shear flow. Thus if it is assumed that the random field which is defined by the correlation function is composed of an ensemble of groups of internal waves propagating on the background of a depth-varying mean flow, then the direction of the maximum correlation, which coincides with direction of propagation of long internal waves, should vary with depth.

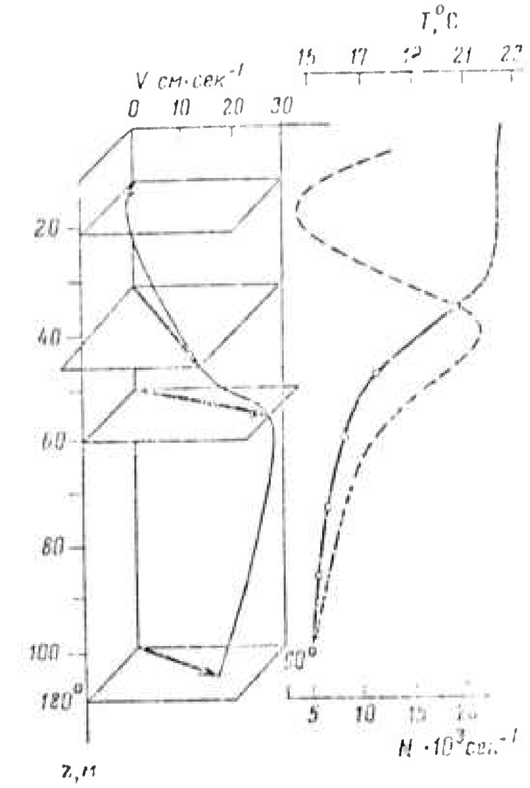


Fig. 1. Vertical profiles of temperature, Vaisalaa frequency, flow velocity, and flow direction (open circles indicate temperature sensors).

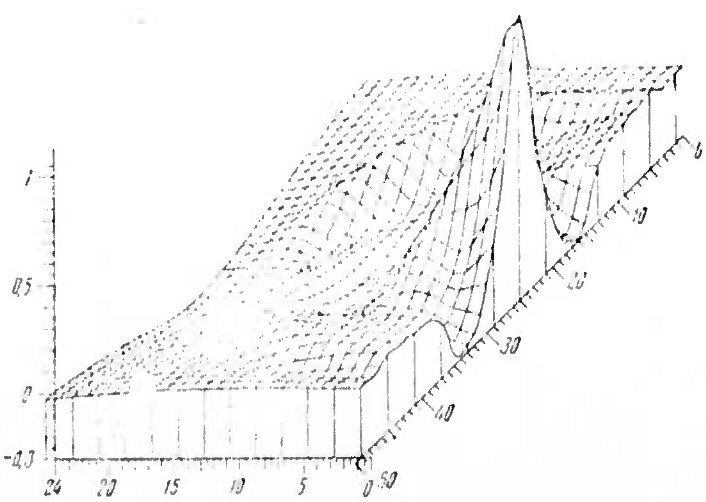


Fig. 2. Two-dimensional correlation for temperature fluctuations at a depth of 35 m.

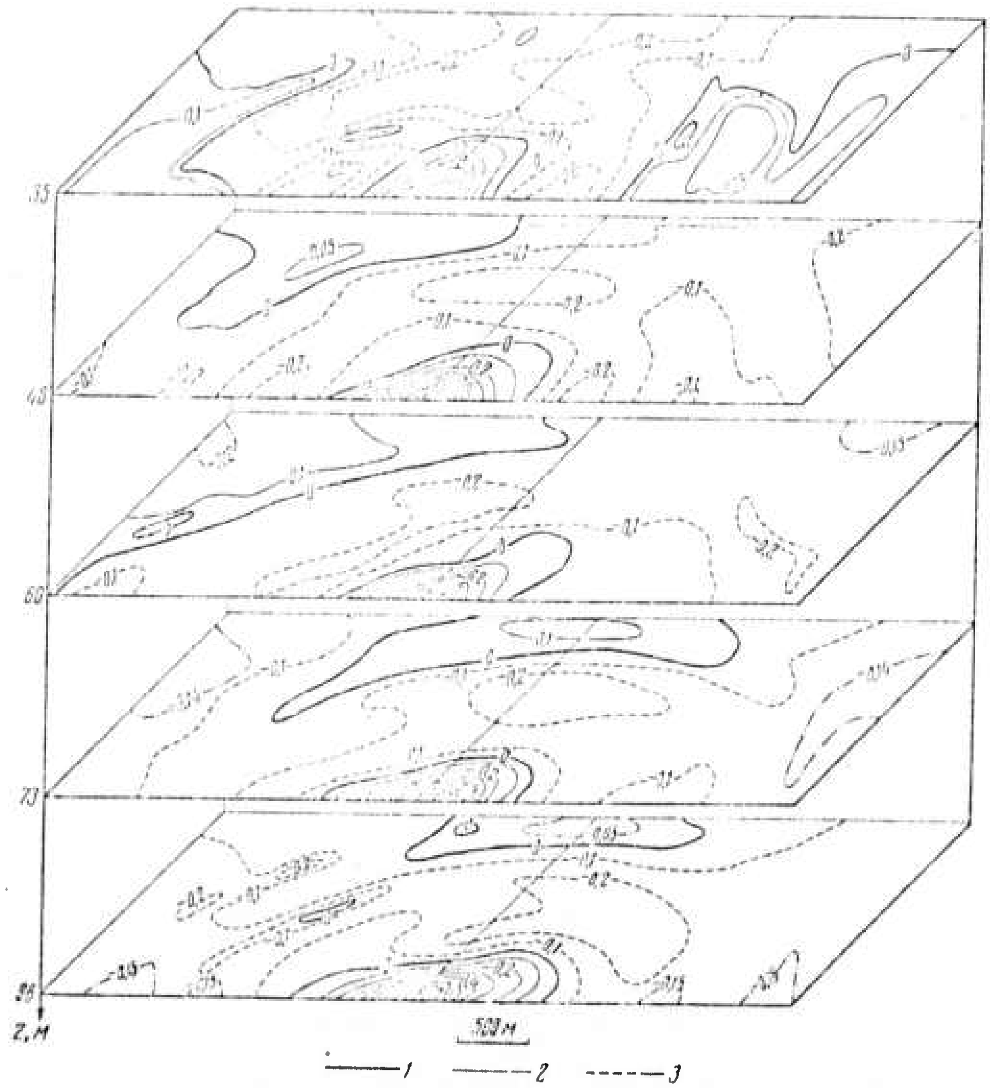


Fig. 3. Two-dimensional correlation for temperature fluctuations at depths of 35, 48, 60, 73, and 86 m.

Kublanov, Ya. M., and N. N. Rakhmanin. The problem of the angular energy spectrum of sea waves. IN: Teoriya voln i raschet gidrotekhnicheskikh sooruzheniy. Moskva, Nauka, 1975, 67-76. (RZhMekh, 9/75, #9B412). (Translation)

Some features of the angular distribution of energy of surface waves are studied on the basis of available field data. It is shown that the Arthur-Pierson hypothetical relationship is not a universal one. The angular energy spectrum can be more satisfactorily described by a generalized sinusoidal-exponential function whose exponent is a function of frequency. Suggestions are given as to the use of the indicated frequency dependence of the exponent in hydraulic engineering.

Larichev, V. A., and G. M. Reznik. Nonlinear stationary Rossby waves. (Paper presented at the seminar on geophysical hydrodynamics at the Oceanographic Commission of the USSR Academy of Sciences, 1975). (Okeanologiya, no. 5, 1975, 936)

This paper describes a theoretical study of short nonlinear stationary Rossby waves, propagating on a background of a slowly-varying mean flow. In the authors' view, their treatment of the problem can be used to explain a number of experimental findings on the behavior of meso-scale ocean vortices, obtained during the Soviet Polygon-70 and the U.S. MODE-1 programs.

Leonov, A.I., and Yu. Z. Miropol'skiy. Short-wave approximation in the theory of stationary nonlinear internal gravity waves. FAiO, no. 11, 1975, 1169-1178.

A study is reported on short stationary internal gravity waves propagating in an unbounded stratified fluid. Equations are developed for the spatial evolution of wave parameters, corresponding to an adiabatic approximation. Weakly nonlinear periodic internal waves are considered, and it is shown that these are unstable in the case of lateral perturbation (self-focusing). For weakly nonlinear waves in an unbounded stratified fluid a stable formation would be a solitary internal wave, or soliton. The spatial evolution of solitons is also analyzed.

Levkov, N. P. Dissipation of internal waves generated by periodic atmospheric disturbances. Morskiye gidrofizicheskiye issledovaniya, no. 2, 1975, 33-44. (R ZhGeofiz, 2/76, #2V104). (Translation)

The effect of viscosity on dissipation of surface and internal waves, generated in a two-layered liquid by periodic normal pressure which is applied to a bounded area, is analyzed. Coefficients of horizontal and vertical momentum transfer for the two layers are assumed to differ. It is established that momentum transfer considerably affects the amplitudes of both surface and internal waves. The effect of layer thickness on damping decrement of internal waves is discussed; the dependence of damping decrement of internal waves on differential density for the two layers is also treated.

Matushevskiy, G. V. A method of distinguishing between wave and turbulent motions in the near-surface layer of the sea. IN: Trudy Gosudarstvenogo okeanograficheskogo instituta, no. 126, 1975, 142-151. (RZhMekh, 1/76, #1B927). (Translation)

Quasiregular surface waves excite turbulent motion in the near-surface layer of the sea, in which regions of wave and turbulent motion overlap. In previous studies it was shown possible to distinguish turbulent fluctuations either by scalar quantities or bythe vertical component of orbital velocity. In the present work the problem of separation of horizontal velocity components is solved in the framework of the theory of linear filtering which was developed by Yaglom.

To solve this problem, information on the spectrum of the summary process is needed as well as information on a process that is linearly related to the wave portion of the summary process. Such a process is fluctuations of slopes of a sea surface. Coherence functions for slopes and summary velocities are obtained which permit segregation of the spectra of wave and turbulent motions. The problem can be solved both for the case of known and unknown frequency characteristics of the linear transformation cited above. The same procedure can be applied to Reynolds stress.

Miropol'skiy, Yu. Z. Internal waves: inertial oscillations. (Paper presented at the seminar on geophysical hydrodynamics at the Oceanographic Commission of the USSR Academy of Sciences, 1975). (Okeanologiya, no. 4, 1975, 763. (Translation)

This article contains a sequential presentation on the theory of internal waves and inertial oscillations. Special attention is paid to nonlinear effects which originate during propagation of internal gravity waves.

Miropol'skiy, Yu. Z. The effect of shear flow on generation of short-period internal waves in the ocean. FAiO, no. 9, 1975, 933-941.

The question of internal gravity wave generation by random variations in atmospheric pressure is analyzed. The author assumes a two-layer ocean model with discontinuities in vertical density and in horizontal flow velocity. The growth rates of both stable and unstable internal waves are considered. It is shown that under resonance

conditions, the spectrum of vertical displacements in internal waves with small wave numbers increases linearly with time, while for large wave numbers it grows exponentially.

Miropol'skiy, Yu. Z. Instability of weakly nonlinear waves in anisotropic dispersive media, as applied to internal gravity waves and Rossby waves. DAN SSSR, v. 223, no. 4, 1975, 848-851.

The Lighthill criteria for instability of stationary waves propagating in an isotropic medium are generalized for an anisotropic medium. The problem is reduced to solving the equation for general phase and the equation for energy transfer, which are given in the form

$$\varphi_t + u_j \varphi_{x_j} + \frac{1}{2} \frac{\partial u_j}{\partial k_i} \varphi_{x_i} \varphi_{x_j} + \alpha a^2 = 0 \qquad (1)$$

$$\frac{\partial a^2}{\partial t} + \sum_j \frac{\partial}{\partial x_j} \left\{ \left[u_j + \frac{\partial u_j}{\partial k_j} \varphi_{x_j} \right] a^2 \right\} = 0 \qquad (2)$$

Eqs. (1) and (2) constitute a closed system which in adiabatic approximation defines the evolution of amplitude and phase of nonlinear waves in an anisotropic dispersive medium. It is further assumed that a linear wave packet with wave numbers $k_j^{(0)}(x_i, t)$ and amplitudes $a_0(x_i, t)$ is subjected to a small disturbance, $a = a_0 + A$ where $A \ll a_0$ and $\varphi_{xj} \ll k_j^{(0)}$. After eqs. (1) and (2) are linearized with respect to A and φ_{xj} and phase is defined by $\Psi = \varphi + \alpha a_0^2 t$ the following equation system is obtained:

$$\Psi_t + u_j \Psi_{x_j} + 2\alpha a_0 A = 0 \qquad (3)$$

$$A_t + u_j A_{x_j} + \frac{1}{2} a_0 \sum_j \frac{\partial u_j}{\partial k_j} \Psi_{x_j x_j} = 0 \qquad (4)$$

Eqs. (3) and (4) have solutions in the form $\Psi = \Psi_0 \exp\{i(\varkappa_j x_j - \sigma t)\}$ and $A = A_0 \exp\{i(\varkappa_j x_j - \sigma t)\}$ when the following dispersion equation is satisifed:

$$\sigma = \varkappa_j u_j \pm |a_0| \Delta^{1/2}, \quad \Delta = \sum_j \alpha \varkappa_j^2 \frac{\partial u_j}{\partial k_j} \qquad (5)$$

It follows from eq. (5) that nonlinear waves are stable when $\Delta > 0$, and unstable when $\Delta < 0$. For an isotropic medium where only one component of group velocity exists, this becomes Lighthill's criterion.

Using results of Leonov and Miropol'skiy (1975) for weakly nonlinear short internal gravity waves in an unbounded stratified liquid, the author obtains

$$\Delta = \bar{\alpha} \Omega k_1^2 (k_1^2 + k_2^2)^{-3} [(2k_2^2 - k_1^2)\varkappa_2^2 - 3k_2^2 \varkappa_1^2] \qquad (6)$$

where $\bar{\alpha} = {}^3/_4 \Omega_{x_m x_m} \Omega^{-1/2} - {}^5/_3 \Omega_{x_1}^2 \Omega^{-1/2}$.

It is apparent that when $\bar{\alpha} < 0$ waves are stable with respect to purely longitudinal disturbances ($\varkappa_2 = 0$), but are nonstable with respect to merely transverse ones ($\varkappa_2 = 0$) if $k_1^2 < 2k_2^2$. However, if $k_1^2 > 2k_2^2$, $\Delta > 0$ and no growing disturbances exist.

As far as Rossby waves are concerned, when $|\nu| = \pi/4$ $(\varkappa_1^2 = \varkappa_2^2)$ they are neutral with respect to disturbances. When ν assumes arbitrary values, waves that propagate at angles $|\Phi| = \pi/6; \pi/2$ are neutral as well. When $\bar{\alpha} > 0$, waves that propagate at an angle $|\Phi| < \pi/6$ are unstable with respect to transverse disturbances; and those that propagate at angles $\pi/2 > |\Phi| > \pi/6$ are unstable with respect to longitudinal disturbances. When $\bar{\alpha} < 0$ the converse applies. At $\Phi = 0$ and $\Phi = 52^{\circ}$, $|\Delta|$ reaches maxima. Thus, excluding the special cases when $\Phi = \pi/6$ or $\pi/2$, Rossby waves are unstable with respect to one or another disturbance regardless of the sign of $\bar{\alpha}$ which is determined by behavior of mean flow $U(x_2)$.

The author notes in closing that the results obtained are valid only if $\varkappa_j \gg L_j^{-1}$, where L_j is a characteristic scale of wave fluctuations along x_j.

Morozov, Ye. G., Ye. A. Plakhin, and S. M. Shapovalov. Study of temperature fluctuations within the frequency range of internal gravity waves in the north-western Pacific Ocean. Okeanologiya, no. 1, 1976, 61-66.

Observations of temperature fluctuations using a three-station network (see Fig. 4) were made during June-August 1974. Hydrological conditions in the observation region are illustrated in Fig. 1. The results of spectral analysis of temperature fluctuations are given in Figs. 2 and 3. The parameters of low-frequency internal waves are calculated, using phase relationships, by a method developed by Mirabel' et al. (1973).

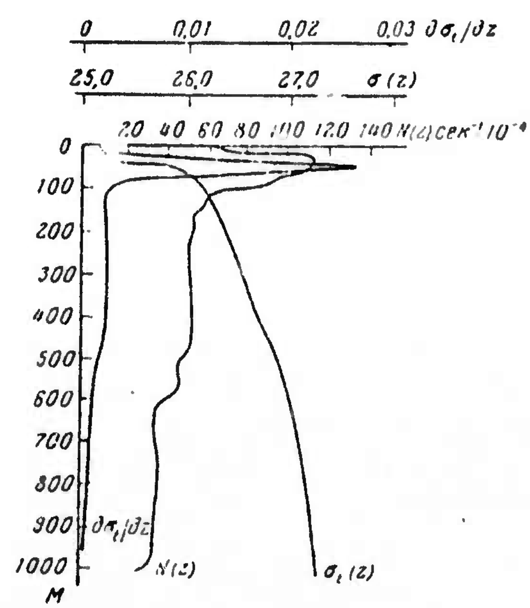


Fig. 1. Vertical profiles of conditional density, conditional density gradient, and Vaisalaa frequency.

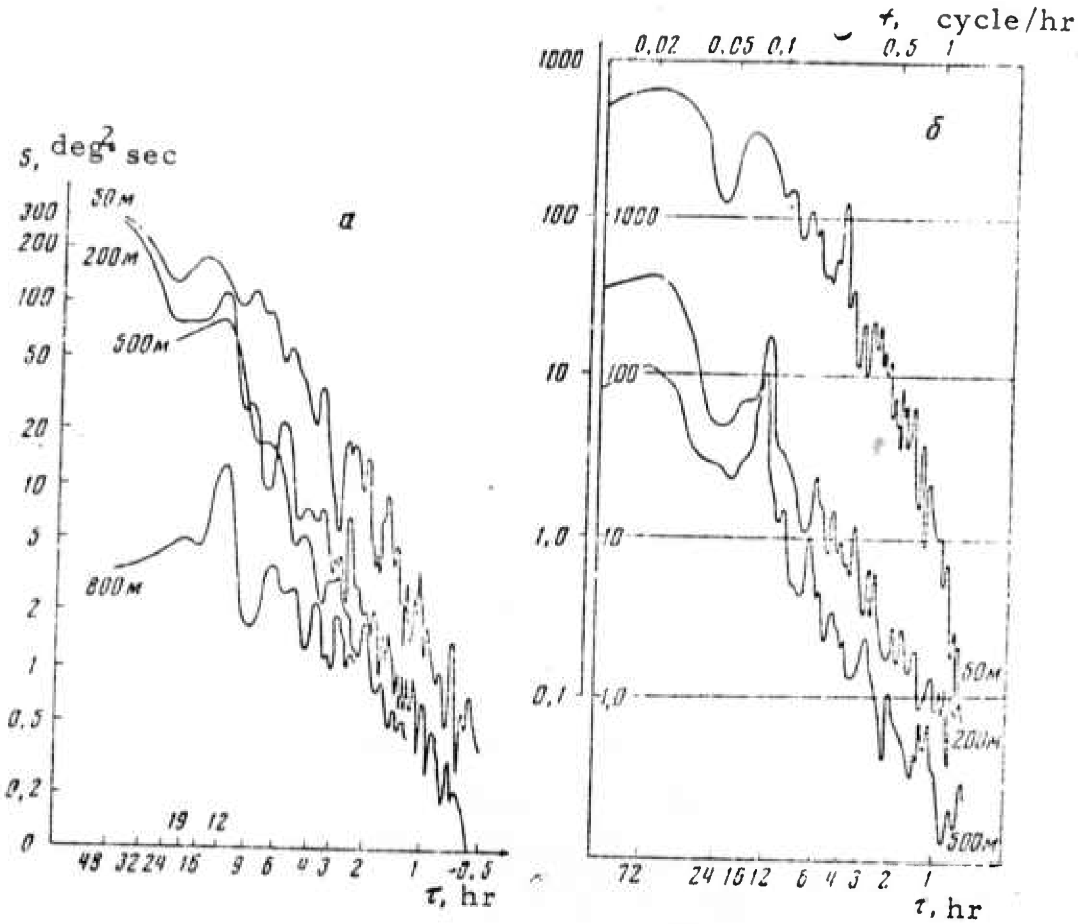


Fig. 2. Spectral densities for temperature fluctuations calculated from 20-day time series (a), and 36-day time series (b). Observations at Station nos. 7020 (50, 200, and 500 m) and 7021 (800 m).

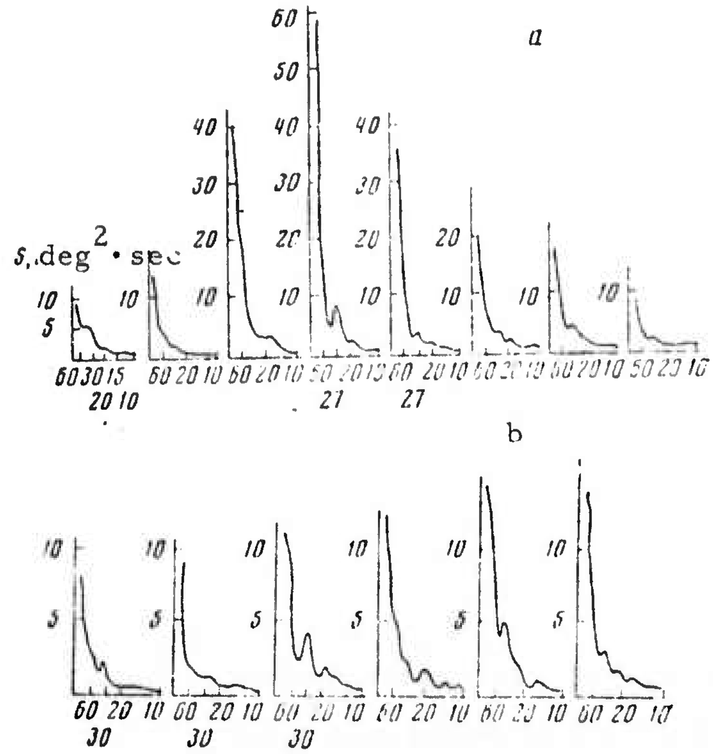


Fig. 3. Time variation of spectral density for temperature fluctuations. Observations at Station no. 7020 (50m) during passage of a large-amplitude wave train (a) and in the absence of same (b).

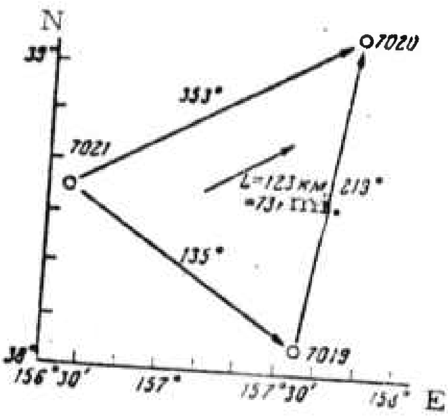


Fig. 4. Phase diagram for calculation of the parameters of internal waves with period of τ = 12.4 hours.

Wavelength, phase velocity, and propagation direction for internal waves with a period of τ = 12.4 hours are found to be 123 km, 2.9m /sec, and northwesterly, respectively. The deduced wavelength agrees well with the theoretical value of 118 km. It was found that temperature fluctuations with synoptic periods are predominant in the spectra (see Fig. 5). Furthermore, inertial temperature fluctuations are identified only in the spectra measured at the 50-m level, in the seasonal thermocline. The authors note that this fact confirms the existence of spatial intermittency of internal waves in the inertial interval.

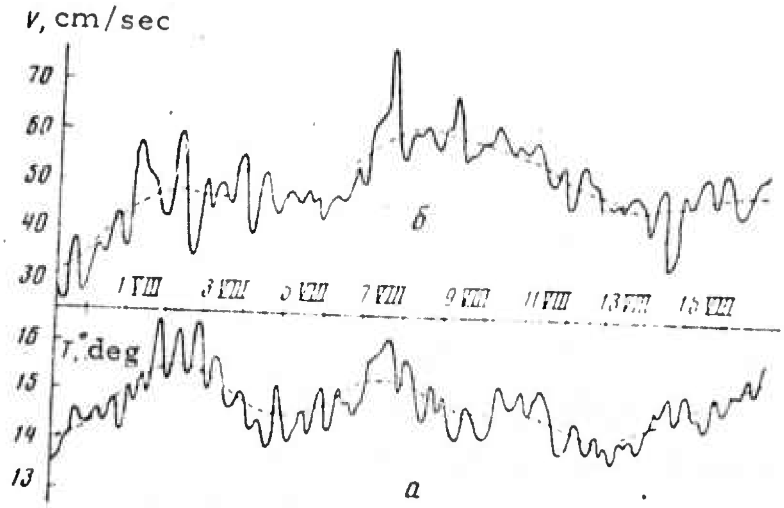


Fig. 5. Synchronous observations of temperature and flow velocity in the seasonal thermocline.

Morozov, Ye.G. Experimental study of internal waves in tides. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 17-20. (RZhGeofiz, 12/75, #12V113). (Translation)

Internal waves with tidal periods are studied using temperature measurements made from buoy stations in various regions of the World Ocean. Lengths and propagation directions of waves are calculated.

Murav'yev, S. S. The problem of coefficient of horizontal turbulent diffusion in the surface layer of the sea. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 109-112. (RZhMekh, 10/75, #10B479). (Translation)

A review is given of works concerning the study of coefficient of virtual horizontal turbulent diffusion in the inertial interval. The conclusion is made that horizontal distribution of tracer concentration satisfies a normal distribution law and that the 4/3 and 2/3 power laws are valid in the inertial interval.

Naumenko, M. F. Characteristics of spatial inhomogeneties in the surface temperature field of the ocean. Morskiye gidrofizicheskiye issledovaniya, No. 2, 1975, 96-107. (RZhGeofiz, 2/76, #2V112). (Translation)

An analysis is made of measurements of surface temperature in the ocean. Measurements were made by towed temperature sensors during the 20th, 21st, 25th, and 26th cruises of the R/V Mikhail Lomonosov in the Atlantic Ocean. The method for calculating parameters of temperature inhomogeneities from experimental data is described. As a measure of inhomogeneity the variance is used, determined by statistical analysis of temperature records. The following empirical characteristics of temperature inhomogeneities are plotted: scale spectrum; distribution of small-scale inhomogeneities; and distributions of variance for inhomogeneities with various scales. It is concluded that distribution of scales (and amplitudes) of temperature inhomogeneities satisfies a log normal distribution law irrespective of measurement region and weather conditions. A broader classification of temperature inhomogeneities is proposed, including small-scale inhomogeneities which originate under windless

conditions and which generate large-scale inhomogeneities through interaction processes.

Nekrasov, V.N., and Yu. D. Chashechkin. A method for determining the velocity and period of free internal oscillations in stratified media. IN: Fizicheskiye metody issledovaniya prozrachnykh neodnorodnostey. Moskva, 1975, 84-86. (RZhMekh, 1/76, #1B1238). (Translation)

A method is described for determining the velocity and period of free oscillations in stratified media, using optical recording. The sinking rate of the column of hydrodynamic wake of an emerging bubble is recorded by shadow or interference instruments. The method allows one to determine fluid velocities above 10^{-2} cm/sec with an error of $\pm 2\%$, and periods of free internal oscillations with an error of $\pm$ 0.5% at spatial resolution of 0.1cm.

Ozmidov, R.V. Turbulence in the ocean. (Paper presented at the seminar on geophysical hydrodynamics at the Oceanographic Commission of the USSR Academy of Sciences, 1975). (Okeanologiya, No. 4, 1975, 763)

The author gives a comprehensive review of experimental data on oceanic turbulence which were collected during recent expeditions organized by the Institute of Oceanology of the Soviet Academy of Sciences. He also discusses new concepts of the origin of small-scale turbulence in a stably stratified medium, which is associated with fine thermohaline structure.

Poberezkin, S. M. Diffraction of internal Kelvin waves at a semi-infinite barrier. IN: Sbornik nauchnykh trudov Kuybyshevskogo politekhnicheskogo instituta, no. 7, 1974, 76-81. (RZhMekh, 12/75, #12B504). (Translation)

The three-dimensional problem of motion of a perfect incompressible fluid with a finite constant depth, unbounded in the horizontal direction, is considered. The fluid rotates about a vertical axis at a constant velocity. The original equation system consists of linearized equations of motion, mass, and volume. Disturbed motion is assumed to be periodic. The problem of diffraction of Kelvin waves is studied by defining incident waves as a superposition of normal modes and assuming that they propagate along one side of a semi-infinite vertical barrier.

The use of the integral Fourier transform reduces the problem to the Wiener-Hopf equation for reflection. An asymptotic representation of the solution is obtained by the method of steepest descents. An analysis of the asymptotic solution shows that short-period waves are almost entirely stopped by the barrier, whereas the amplitude of scattered cylindrical waves is large. Conversely, long-period waves are almost entirely transmitted to the other side of the barrier. In the region without a barrier, waves are almost absent.

Pokazayev, K. V. Experimental study of wind waves in a turbulent flow. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 92-94. (RZhGeofiz, 11/75, #11V105). (Translation)

Experiments were carried out in aerohydrodynamic channel with a depth of 70 cm. Wind speed at a distance of 20 cm from the undisturbed surface was 8-14 m/sec. Turbulent flow was generated by a submerged jet with horizontal axis. The observed wave damping, which occurs to a greater extent than was reported by Huang (1972), is apparently caused by turbulence.

Shtentzel', V. K. A new direction in development of the theory of waves on a water surface. IN: Trudy Koordinatsionnogo soveshchaniya po gidrotekhnike, no. 92, 1974, 11-15. (RZhGeofiz, 10/75, #10V75). (Translation)

The concept of a "liquid particle" which is introduced by the author into analysis of the dynamics of wind waves, and the process of deformation of the particle during orbital wave motion, are discussed; allowance should be made for the effects of particle deformation in an analysis of orbital motion. Particle deformation will have different magnitudes and signs at various wave phases. Approximate wave equations are derived allowing for effects of particle deformation. These equations are consistent with data laboratory experiments.

Tsvetkova, A. A. Computation of currents and density fields in the World Ocean. IN: Chislenyye metody rascheta okeanicheskikh techeniy. Novosibirsk, 1974, 21-42. (RZhGeofiz, 6/75, #6V59). (Translation)

Calculations are given for flows and density fields in the World Ocean. Calculations are made using linear equations of motion with allowances for horizontal and vertical turbulent exchange. On the surface of the ocean, density and tangential wind stress are defined. At solid boundaries, adherence and an absence of perpendicular density flux are assumed. The problem is reduced to a two-dimensional equation for flow function, and a three-dimensional equation for density transfer. The results of calculations demonstrate the existence of counter-flows beneath many surface currents. Flow rates for the major currents are: Antarctic - 170 x 10^6 m^3/sec, Gulf Stream - 70 x 10^6 m^3/sec, and Kuroshio, 71 x 10^6 m^3/sec.

Tsyganov, V. F. A method for computing the coefficient of vertical turbulent viscosity. IN: Trudy Atlanticheskogo NII rybnogo khozyaystvu i okeanografii, no. 58, 1975, 56-63. (RZhGeofiz, 11/75, #11V61). (Translation)

A system of dynamic equations for the surface sea layer is solved for the case of a neutral stratification. The system consists of the turbulent energy balance equation, Kolmogorov's formula for eddy viscosity coefficient, and the Karman equation. It coincides with the one for atmospheric boundary layer as proposed by Zilitinkevich and Laykhtman (Trudy GGO, no. 67, 1965). A formula is obtained which makes it possible to devise an

iterative procedure for simultaneous calculation of vertical profiles for flow velocity and eddy viscosity coefficient.

Vasilenko, V. M., M. M. Lyubimtsev, and R. V. Ozmidov. On fluctuations in the dissipation rate of turbulent energy and high order structural functions for a velocity field in the ocean. FAiO, no. 9, 1975, 926-932.

Calculated results of structural functions up to the 13th order are discussed for turbulent velocity fluctuations in the ocean. Values of the constant $\mu_{p/3}$ in the expressions for moment of dissipation rate of turbulent energy, $< \epsilon_r^{p/3} > \quad r^{-\mu p/3}$, are estimated in the inertial subrange of scales r, based on power intervals of the structural functions. The dependence of $\mu_{p/3}$ on p is found to be approximately linear, at least for p >6. Experimental data obtained compare reasonably well with the theoretical model.

Vasil'yev, A. S. Hydrodynamic model of nonlinear interaction of flow and density fields. Sb. Morskiye gidrofizicheskiye issledovaniya, no. 4, Sevastopol', 1974, 5-16.

A method is proposed for calculating flow velocity at various depths, densities and coefficients of turbulent mass exchange in a water basin with an arbitrary shoreline and bottom relief. A nonstationary, nonlinear

case is considered in a hydrostatic approximation. Three variants of density models are treated. The author points out that none of the three density models include the fundamental defect of the density model used by Shtokman (1951) and several others. The latter model, which has been used in studying the dynamics of currents at various depth in the framework of a quasigeostrophic baroclinic ocean, was constructed without accounting for density diffusion.

Volosov, V.N. <u>Nonlinear topographic Rossby waves</u>. (Paper presented at the seminar on geophysical hydrodynamics at the Oceanographic Commission of the USSR Academy of Sciences, 1975). (Okeanologiya, no. 5, 1975, 936-937).

Nonlinear topographic Rossby waves in a barotropic ocean with a bottom relief which is anisotropic in one direction are studied, using the traditional approximation of an infinite β -plane and a rigid cover. A linear theory of topographic Rossby waves with infinitesimal amplitudes was advanced by Rhines and Bretherton in 1973. In the present work this theory is generalized, and a nonlinear theory of topographic Rossby waves with arbitrary amplitudes is developed.

Volovov, V.I., and V.V. Krasnoborod'ko. Method for recording the surface wave motion of fluids. Otkr izobr, no. 44, 1975, 93. (Translation)

An ultrasonic method is proposed for recording surface waves in fluids. The method is devised to measure accurately surface waves with amplitudes smaller than half the length of the ultrasonic waves. This is achieved by measuring the amplitude of standing waves which are generated near the surface. A partially submerged tubular receiver is set vertically above the source of harmonic ultrasonic waves. Deviation of the level of the fluid surface from the mean level is determined from the amplitude of the recorded signal, using a calibration curve.

Volovov, V.I., V.V. Krasnoborod'ko, and Yu. P. Lysanov. Acoustic method for determining sea wave height. Author's Certificate USSR, no. 412578, published Aug. 19, 1974. (RZhGeofiz, 2/76, #2V40P). (Translation)

In order to broaden the application of acoustic methods for determining sea wave height, two submerged transmitter/receiver systems are spaced along the vertical. Two pulsed acoustic signals with a frequency difference proportional to relative vertical spacing are excited. Reflected signals are filtered, their envelopes are detected, and the frequency-spatial correlation coefficient for the envelopes is measured. Sea wave

height is then determined by $\sigma = [-2^{-1} \ln B(f_1, f_2)]^{1/2}/\pi K$, where $B(f_1, f_2)$ is cross correlation, and ΔK is differential wave number.

Voronin, V.A., L.F. Lependin, and S.F. Cherepantsev. Emission of acoustic energy by a turbulent oceanic layer. Prikladnaya akustika, no. 1, Taganrog, 1975, 40-47. (RZhF, 12/75, #12Zh915). (Translation)

Results are given on calculations of dissipation rate of kinetic energy of a turbulent sea under a stationary thermal regime. On the basis of these results a spectrum of low-frequency sea noise is calculated. The results are in agreement with those reported by other authors.

Voronovich, A.G., A.I. Leonov, and Yu. Z. Miropol'skiy. A possible mechanism for formation of fine structures in hydrophysical fields in the ocean. (Paper presented at the seminar on geophysical hydrodynamics at the Oceanographics Commission of the USSR Academy of Sciences, 1975). (Okeanologiya, no. 1, 1976, 189-190). (Translation)

A theory is proposed which postulates generation of fine structures of hydrophysical fields in the ocean by weakly nonlinear packets of internal gravity waves. The theory of nonstationary weakly nonlinear internal waves, earlier developed by the authors (FAiO, no. 3, 1976), shows that a wave packet generates mean flow velocity and mean density fields independent of wave period, which are proportional to the square of amplitude, analogous to the Stokes flow in the theory of finite-amplitude surface waves.

The results of the present work show that packets of weakly nonlinear waves generate vertical microstructures in mean velocity and density fields, as well as in mean pressure fields; the shorter the horizontal wavelength of internal waves in a packet, the more pronounced will be the vertical microstructure. Furthermore, numerical calculations of fine vertical structure of mean velocity and density fields for typical oceanic conditions show that the theory proposed is consistent with all available experimental data on fine structure of hydrophysical fields in the ocean.

Yefimov, V. V., and A. S. Zapevalov. *Spectral characteristics of temperature pulsations in a layer of wind waves.* Okeanologiya, no. 4, 1975, 592-598.

Simultaneous measurements of fluctuations in temperature t', vertical velocity ω', and surface elevation, η' are reported in the uppermost ocean layer (0.7 - 2.0m) as measured from a gradient mast. The mast was mounted in 15m deep water, 300m offshore. Results of the measurements are summarized in Fig. 1-3; the article also includes tabulated data for eight series of measurements.

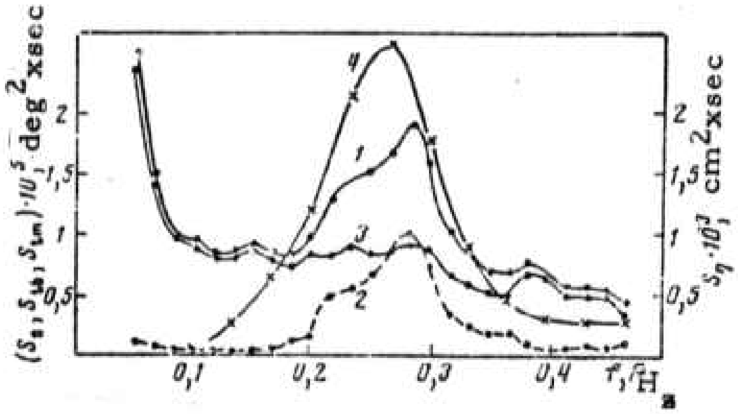


Fig. 1. Energy spectra of t' at a depth of 0.8m (curves 1-3), and of η' (curve 4) in the case of wind waves.
1-summary spectrum; 2-coherent (wave) component; 3-incoherent (turbulent) component.

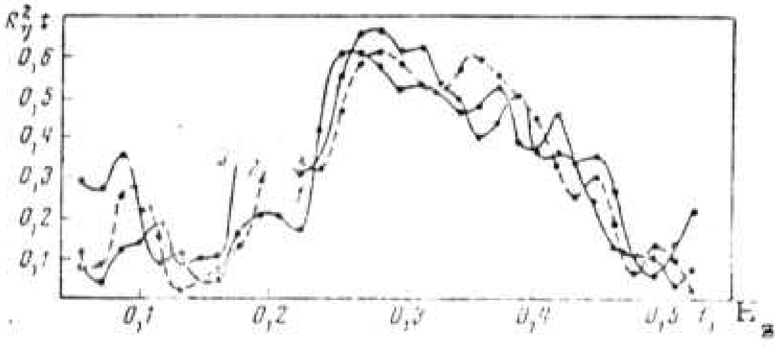


Fig. 2. Squared coherence function for η' and t' at depths of 0.8m (curve 1), 1.3m (2), and 1.8m(3) for the case of mixed waves.

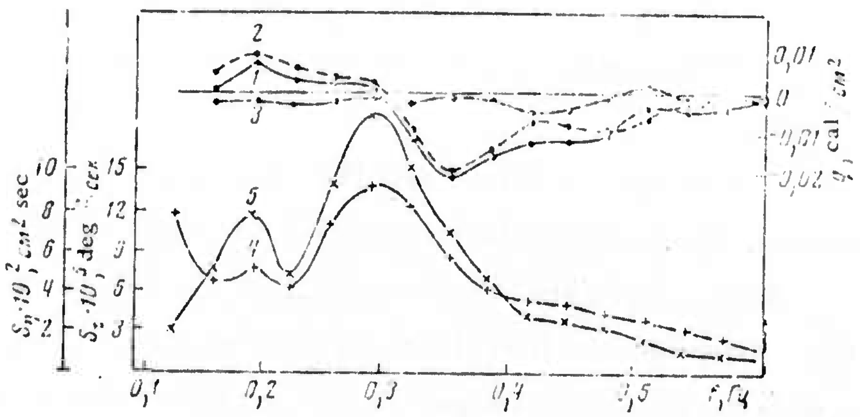


Fig. 3. Spectra of heat flux at a depth of 1.3m (curves 1-3), t' (4), and η' (5) for the case of mixed waves.

1-summary spectrum; 2-coherent (wave) component; 3-incoherent (turbulent)component

It was found that the turbulent component of the spectrum of temperature fluctuations can be approximated by a 1.6 power law. Furthermore, the $R^2_{\eta t}$ curves in the case of wind waves have a lower level and drop off faster at high frequencies than those in the case of swells. The cited results agree well with experimental data obtained in the Mediterranean (Benilov, 1973). According to those data, "wave noise" at a depth of 0.5m at the energy-bearing frequency represents 45% of the summary spectrum.

Zaytsev, A. A. Free and induced Kelvin waves near the shore of a stratified ocean. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 73-77. (RZhGeofiz, 11/75, #11V107). (Translation)

It is demonstrated that the existence of Kelvin waves is possible in a rotating incompressible stratified fluid with a single boundary, i.e., a vertical plane. The generation mechanism for Kelvin waves is associated with the waveguide effect at the perimeter of the rotating fluid. This effect is manifested in the fact that a part of the energy of shore-bound internal waves is spent on generation of boundary Kelvin waves. The problem of generation of Kelvin waves by pulsed and harmonic point sources in the ocean is considered. Numerous characteristics of stationary and non-stationary Kelvin waves are analyzed and zones of wave propagation are indicated.

Zaytsev, A. A. Some features of propagation of nonstationary internal waves in the ocean. IN: Kompleksnyye issledovaniya v Mirovom okeane. Moskva, 1975, 7-11. (RZhGeofiz, 11/75, #11V116). (Translation)

An analysis is made of nonstationary internal waves, generated by fluctuations of atmospheric pressure. The waves are assumed to propagate in an incompressible stratified ocean of constant depth. Two forms of solution of the boundary value problem with initial conditions for induced internal waves are obtained. Using the method of stationary phase the author established that after passage of fronts of incident waves together with reflected and normal wave through a given zone, each internal wave in the zone breaks down into two waves. Characteristic features of these wave types are analyzed.

Zhurbas, V. M., S. S. Murav'yev, and T. M. Tatarayev. Experimental study of turbulent diffusion of tracer streams in the near-surface layer of the sea. Okeanologiya, no. 4, 1975, 611-615.

Seven experiments were carried out in the Caspian Sea in 1973, using the experimental procedure shown in Fig. 1. One experiment was also done in the Black Sea in 1965 using a Karabashev fluorimeter. The experiments were designed to allow observation of dye tracer diffusion in 1-10 min and 1-90 min time intervals. The experiments were accompanied by measurements of wave height and flow velocity. Apparent widths of the dye stream were converted into dye dispersion on the basis of Roberts'

theory of "visibility through smoke". The results of measurements of dye dispersion are shown in Fig. 2, and calculations of dissipation rate are shown in Fig. 3.

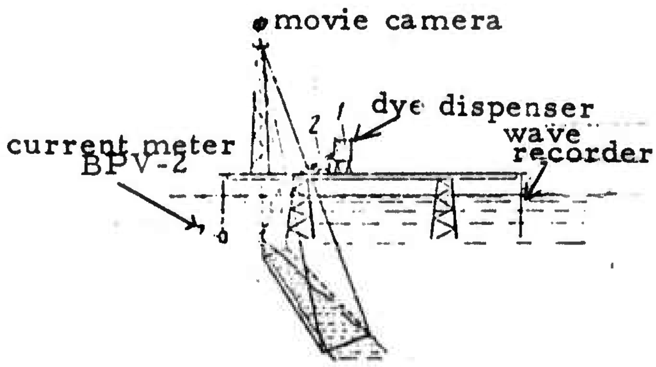


Fig. 1. Experimental set-up

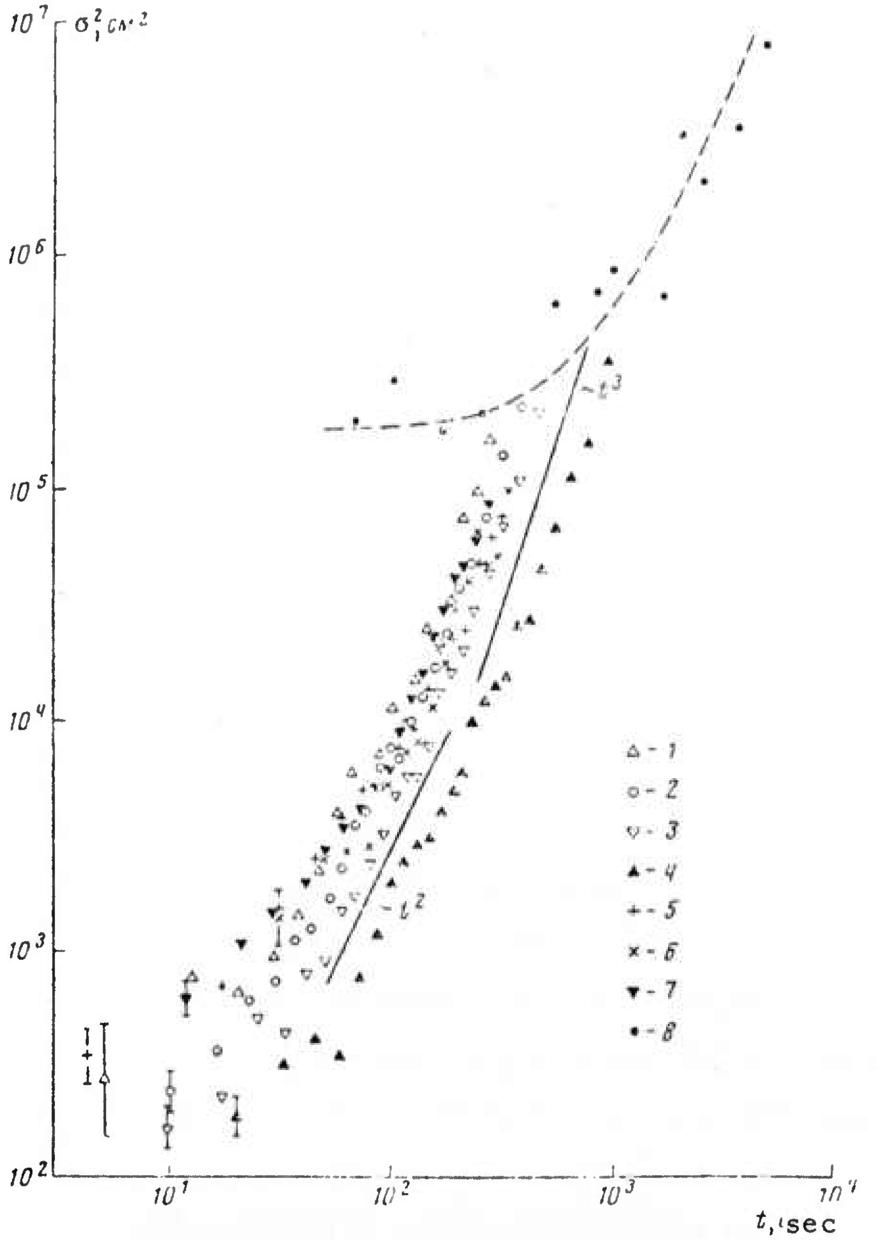


Fig. 2. Dependence of transverse dispersion of dye stream on diffusion time.
1-7 - experiments in the Caspian Sea;
8- experiment in the Black Sea;
solid and dashed lines are calculated.

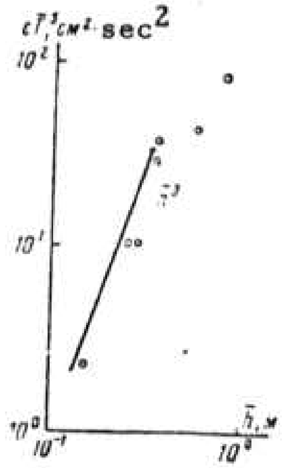


Fig. 3. Relationship between dissipation rate of turbulent energy and period and height of waves. Solid line is calculated.

The authors point out that the experimental results of Fig. 2 agree well with theoretical findings on relative diffusion in the field of a locally isotropic turbulence. The results thus give evidence of existence of an inertia turbulence interval within the 1-10 min diffusion time range. It is also suggested that the quadratic section of the dashed curve in Fig. 2 represents the beginning of another, mesoscale inertia interval.

The calculated values of dissipation rate of turbulence energy for small wave heights adequately satisfy the theoretical relationship (Fig. 3). The energy influx from the atmosphere under the experimental conditions (sea state 2), calculated assuming the existence of two inertia intervals, is found to be $\Delta\epsilon = \epsilon - \bar{\epsilon} = 1.45 \times 10^{-2} cm^2 \cdot sec^{-3}$.

2. Surface Effects

Bass, F. G., S. Ya. Braude, A. I. Kalmykov, A. V. Men', I. Ye. Ostrovskiy, V. V. Pustovoytenko, A. D. Rozenberg, and I M. Fuks. Radar methods for studying ocean waves. UFN, v. 116, no. 4, 1975, 741-743.

Basic principles and application of radar methods for studying ocean waves are reviewed briefly. The following parameters of ocean waves were measured in the hectometer and decimeter ranges: wave intensity and wind velocity from measurements at a single frequency; direction of wave propagation; distribution of wave heights and spatial spectra from measurements at several frequencies; and distribution of wave intensity over a large area. The parameters of ocean waves measured in the UHF range were: distribution of wave periods; relative wave energy spectra; 90 percentile wave height (from amplitude characteristics), and instantaneous wave heights (from phase characteristics); spatial wave spectra; and orbital velocity spectra. The cited radar methods also enable one to map the intensity of oil spills, as well as the distribution of ripples over a large wave.

The authors note that a two-scale model of radio backscatter by ocean waves is also effective for large grazing angles. This offers a possibility for a solution of the inverse problem based on airborne and space-borne measurements.

Belich, R. B., A. G. Gorelik, V. I. Semiletov, and A. V. Frolov. Polarization characteristics of surface radiation at 0.8 cm. IN: XI Vsesoyuznaya konferentsiya po rasprostraneniyu radiovoln. Ch. 3 Tezisy dokladov. Kazan, Kazanskiy universitet, 1975, 149-153. (RZh Radiot, 1/76, #1 G17). (Translation)

This article deals with determination of the characteristics of radio emission from various surfaces (water, ice, snow, soil, clay, sand, concrete, peat, and grass), employing ground-based measurements at 0.8 cm. Measurements are performed with a modulated radiometer using a superheterodyne circuit. Stated sensitivity is 1.5° at a time constant of 2 sec. Antenna pattern width at the half power points is 2.5°, while the scattering coefficient is 0.15. Effects of temperature, moisture, and roughness of a surface on its brightness temperature, as well as emittance at two polarizations and various viewing angles, are analyzed.

Belousov, P. S., Ye. O. Zhilko, A. A. Zagorodnikov, V. I. Korniyenko, V. S. Loshchilov, and K. B. Chelyshev. Studying sea wave parameters with a side-look radar. IN: Sovetsko-Amerikanskiy eksperiment "Bering." Leningrad, Gidrometeoizdat, 1975, 68-79. (RZhGeofiz, 2/76, #2V85). (Translation)

Results are described of radar surveys of a wavy sea surface during the Bering expedition. The airborne radar survey was made from an altitude of 3 km to a $1:10^5$ scale, accompanied by

shipborne wave recording. Two-dimensional spectra of radar images were constructed, and parameters of the wave system (mean wavelength and mean crest length, angular distribution of total energy which can be approximated by a cosinusoidal-exponential function, etc.) were determined. It is noted that spatial spectra of foam streaks can be used for accurate determination of wind direction.

Freylikher, V. D., and I. M. Fuks. Characteristics of scattering from a statistically uneven surface at small grazing angles. IN: XI Vsesoyuznaya konferentsiya po rasprostraneniyu radiovoln. Ch. 3. Tezisy dokladov. Kazan', Kazanskiy universitet, 1975, 15-17. (RZhRadiot, 1/76, # 1G18). (Translation)

It is shown that the Born approximation cannot be applied to calculations of scattering at small grazing angles.

Fuks, I. M. Determining parameters of sea waves from fluctuations in amplitude and phase of reflected radio waves. FAiO, No. 10, 1975, 1038-1046.

Statistical characteristics are studied in the fluctuations of amplitude χ and phase φ of an r-f signal reflected from a wavy sea surface. It is shown that in the meter and decameter ranges one may determine the rms height of waves from the sum of the dispersions in fluctuation of phase and amplitude, $\langle\chi^2\rangle + \langle\varphi^2\rangle$. The method also applies to sound scattered from a subsurface source.

If the extent of the Fresnel zone is equal to or less than the wavelength Λ_m of the energy-bearing component of the sea wave spectrum, then Λ_m can be found from the expression $\varphi^2 - \chi^2 / \phi^2 + \chi^2$ By measuring the correlation coefficients of fluctuations inf requency-spaced signals, it is also possible to determine Λ_m in the far zone.

Galkin, L. N. <u>Satellite apparatus used for oceanologic observations</u>. Uchenyye zapiski LGU, no. 379, 1975, 29-64. (R ZhGeofiz, 1/76, # 1V31). (Translation)

A review is given of uses and specifications of Soviet and American satellite research equipments. The equipment reviewed includes photographic and TV systems; IR video systems with spatial scanning which operate in single or multiple spectral regions; and IR spectrometers and passive microwave systems. Techniques for relaying of oceanologic and meteorologic information via satellites are described. The probable directions in development of satellite-borne observations are discussed. These efforts should provide for: 1) frequent global surveys with a mean resolution of 10 km; 2) use of satellites with polar orbits covering areas which are inaccessible by geostationary satellites; and 3) more detailed surveys of the earth's surface. Soviet and American satellites and research equipments are tabulated.

Galkin, L. N., and D. I. Maksimikhin. Using satellite data for determination of ocean surface temperature fields from infrared radiation. Uchenyye zapiski LGU, no. 379, 1975, 64-81. (RZ hGeofiz,1/76, #1V43). (Translation)

Descriptions are given of basic principles for determination of surface temperature of sea water, and of the method of analysis of satellite IR data allowing for distinctive features of transmission through the 3.5 - 4.1 μ and 10.5 - 12.5 μ atmospheric windows.

Garnaker'yan, A. A., and A. S. Sosunov. Cross correlation function of frequency-separated r-f signals scattered by a sea surface. IN: XI Vsesoyuznaya konferentsiya po rasprostraneniyu radiovoln. Ch. 3. Tezisy dokladov. Kazan'. Kazanskiy universitet, 1975, 11-14. (RZh Radiot, 1/76, #1G22). (Translation)

Expressions for correlation and its modulus for two frequency-separated r-f signals in the millimeter and centimeter bands, reflected by a sea surface, are derived. It is noted that the expression for modulus of correlation can be used for calculations of sea wave heights.

Garnakeryan, A. A., A. S. Sosunov, and V. V. Timonov. Feasibility of determining ocean wave parameters in the shortwave r-f range from an aircraft. IN: Sb. XI Vses. konf. po rasprostr. radiovoln. Ch. 3. Tezisy dokladov. Kazan', Kazan. un-t, 1975, 154-158. (RZhRadiot, 1/76, no. 1G24). (Translation)

An algorithm is derived for the spatial correlation function of a sea surface which characterizes sea state. A shortwave radar which performs this algorithm has been developed and tested.

Glotov, A. A., M. D. Rayev, D. T. Matveyev, V. G. Mirovskiy, I. A. Troitskiy, and V. S. Etkin. Model measurements on the effect of small-scale surface wave structure on its thermal emission. IN: XI Vsesoyuznaya konferentsiya po rasprostraneniyu radiovoln. Ch. 3. Tezisy dokladov. Kazan', Kazanskiy universitet, 1975. (RZhRadiot, 1/76, #1G35). (Translation)

Model measurements were carried out in an open tank filled with sea water. Small-scale inhomogeneities were induced by two blowers. The degree of inhomogeneity was controlled by changing position of the blowers. Results of the measurements are given.

Gorelik, A. G., and L. V. Knyazev. Calculation of radiothermal and radar characteristics of a wavy sea surface. IN: XI Vsesoyuznaya konferentsiya po rasprostraneniyu radiovoln. Ch. 3. Tezisy dokladov. Kazan', Kazanskiy universitet, 1975, 167-171. (RZhRadiot, 1/76, #1G25). (Translation)

The emission coefficients for horizontal and vertical polarization as well as the effective scattering area are calculated by the Kirchhoff method. The expressions obtained are similar in type to experimental ones, although the theoretical and experimental values differ numerically.

Kalmykov, A. I., A. S. Kurekin, Yu. A. Lementa, M. Ye. Ostrovskiy, and V. V. Pustovoytenko. Effect of reflections, generated by breaking of sea waves, on back-scattering of UHF radio waves. IN: XI vsesoyuznaya konferentsiya po rasprostraneniyu radiovoln. Ch. 3. Kazan', Kazanskiy universitet, 1975, 159-160. (RZhRadiot, 2/76, #2G26). (Translation)

An analysis is given of the fine structure of scattered signals recorded with high range resolution in the presence of breaking sea waves. Bursts in scattering of horizontally polarized signals, which are associated with reflections from wave crests prior to breaking of the waves, were observed.

Kalmykov, A. I., A. S. Kurekim, Yu. A. Lementa, and V. V. Pustovoytenko. Nekotoryye osobennosti obratnogo rasseyaniya radiovoln SVCh diapazona poverkhnost'yu morya pri malykh skol'zheniya. Preprint (Characteristics of backscattering of UHF radio waves by a sea surface, for the case of small grazing angles. Preprint). Khar'kov, 1974, 39 p. (RZhRadiot, 8/75, #8 G36).

Characteristic features of backscattering of centimeter radio waves by a sea surface at small grazing angles ($\psi<8^{\circ}$) are discussed. It is found that some observed phenomena are inexplicable in the framework of the existing scattering model, i.e. "ripples on a large wave". These phenomena include a larger effective scattering cross section at horizontal polarization than at vertical, and a considerable difference between calculated and observed rates of scattering at horizontal polarization. It is noted that bursts of signals are observed during measurement with a high-resolution apparatus. These bursts exceed reflections from ripples. The nature of these bursts is discussed. The cited features of backscattering are explained in the framework of the "ripples on a large wave" model, accounting for bursts. It is shown that "nonstationarity" of reflections, which has been discussed in many papers, is associated with modulation by large waves.

Kanareykin, D. B., and V. A. Potekhin. Statistical polarization characteristics of radar signals reflected from land and water surfaces. IN: XI Vsesoyuznaya konferentsiya po rasprostraneniyu radiovoln. Ch. 3. Tezisy dokladov. Kazan'. Kazanskiy universitet, 1975, 22-24. (RZhRadiot, 1/76, #1G20). (Translation)

A brief review is given of theoretical works on polarization selection of radar signals.

Kireyev, I. V., B. A. Maksimov, and A. V. Svechnikov. Analysis of the energy spectra of sea waves. IN: Sovetsko-Amerikanskiy eksperiment "Bering". Leningrad, Gidrometeoizdat, 1975, 92-99. (RZhGeofiz, 2/76, #2V82). (Translation)

Energy spectra are calculated by applying the Fourier transform directly to wavegrams divided into 6-8 sections, with subsequent averaging of sectional spectra. Distribution of apparent angular frequencies of sea waves are used as auxiliary graphs in the calculations. A description is given of a method for measurement of slopes of a sea surface by recording sea waves at a single point.

Korchagin, Ye. K. and R. N. Semenov. Sea-surface parameters from aerial photographs. IVUZ Geod. i aerofotos'yemka, no. 6, 1974, 67-71.

Height, propagation direction and length of sea-surface waves were measured by aerial photography in the southern Barents Sea in summer at 100 to 300 km. from the coastline. The measurements of wave heights h_1 and h_2 were made from stereograms taken by two airborne synchronized cameras at 100 m. altitude simultaneously from two directions of approach. The h data from over 100 experiments were averaged by the straight line method. The rms error of measured h = 0 to 4 m was $\pm$ 0.15 m.

Direction and wave length of ripples were measured from a single aerial photograph taken by one of the airborne cameras from 800 to 1000 m altitude. In addition, the slope δ of the wave secondary structure was measured by a sun glitter technique on both types of photographs. The $\bar{h}_1/\bar{h}_2$ ratio ($\bar{h}_1 > \bar{h}_2$) of two h values measured in the same experiment from two directions was found to be 1.6 to 2.3 in most experiments. This difference between h_1 and h_2 values was due to the fact that h_1 and h_2 were measured along a straight line parallel to the ripple crest and at 90 degree angle to this line, respectively. Thus, h_1 approximates h_w of wind waves and h_2 represents h_c of composite waves. The average ripple height was evaluated from

$$\bar{h}_з = \bar{h}_c \sqrt{1 - \frac{1}{K_h^2}}, \qquad (1)$$

where $K_h = h_1/h_2$ is the anisotropy factor. Comparison of the experimental h_1 and h_2 values with the h_w calculated from wave shaping wind factors (Figure 1) supports the cited interpretation of the experimental data.

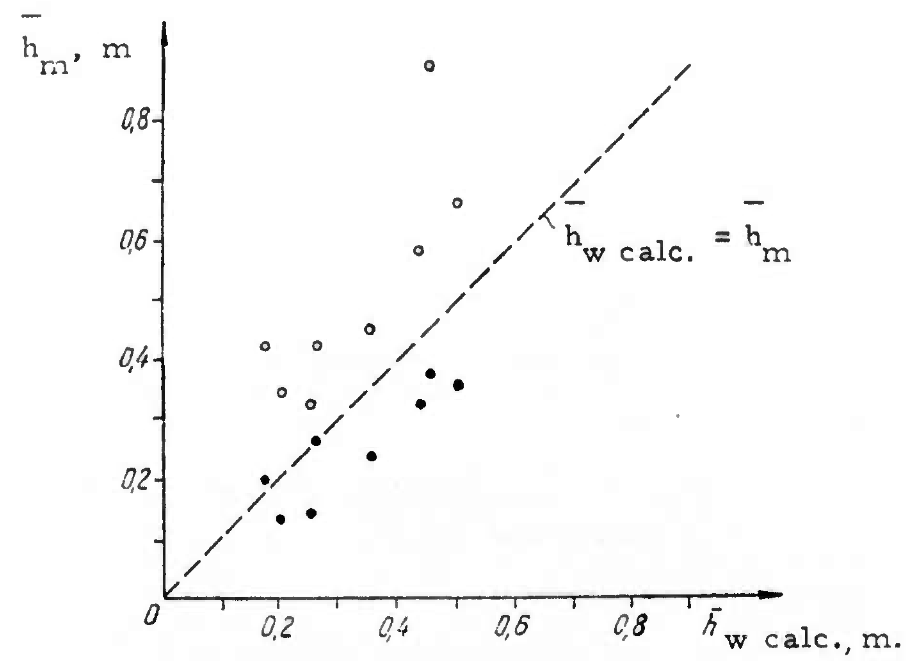


Fig. 1. Experimental wave heights $\bar{h}_m$ versus calculated wind wave heights $\bar{h}_w$ calc. Points - h_1 measured along a line II to ripple crest, circles - $\bar{h}_2$ measured across ripple crest, broken line - $h_m = h_w$ calc. in the absence of ripples.

Thus application of the straight line method requires that the direction of ripples relative to the photographic baseline be taken into account in designing and performing the measurements. The experimental

δ_{max} = 15 to 26 deg. (Fig. 2) are in a good agreement with some earlier data.

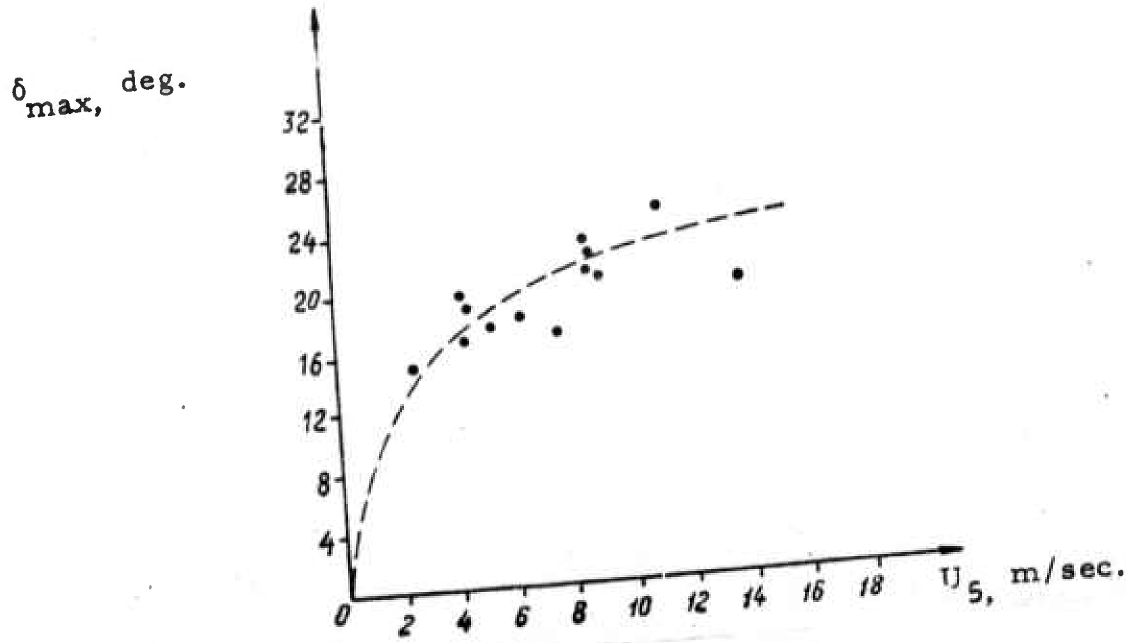


Fig. 2. Experimental δ_{max} vs. wind velocity U_s at the sea surface.

The Beaufort numbers of sea surface, evaluated from the stereograms, were 1 to 2 units higher than degrees of sea roughness corresponding to the measured $h_{\frac{1}{3}}$ values.

Krestnikov, L. A. Effect of sea reflections from the interior of subsurface waveguide. Trudy Sev. Zap. zaochnogo politekhnicheskogo instituta, no. 29, 1975, 74-75. (RZhF, 9/75, #9Zh202). (Translation)

The effect of sea clutter on radar range is analyzed. The possibility of using values of specific effective radar cross section in the presence of waveguides is discussed.

Martsinkevich, L. M., and V. V. Melent'yev. Numerical modeling of thermal r-f emission from the sea surface in the case of stationary and fully-developed sea waves. IN: Trudy Glavnoy geofizicheskoy observatorii, no. 331, 1975, 73-85. (RZhGeofiz, 12/75, #12V29). (Translation)

A study is made of the dependence of sea surface emittance in the centimeter range on the parameters of wind waves (slope, steepness), and on sea water parameters (temperature, salinity) for different signal polarizations. It is shown that sea wave heights can be determined from measured r-f emission from the sea surface.

Logachev, V. P. On the spectrum of amplitude fluctuations in a signal reflected from a surface. IN: Trudy Moskovskogo energeticheskogo instituta, no. 261, 1971, 26-29. (RZhRadiot, 1/76, #1G31). (Translation)

During radar measurements aboard a low-speed aircraft, fluctuations of a signal reflected from an underlying surface arise due to chaotic phase and amplitude modulation. Phase and amplitude are modulated by random processes which are generated by shifting of elementary reflectors. A method is proposed which allows description of the amplitude fluctuations on the basis of a phenomenological model of reflection, and which accounts for the altitude dependence of the spectrum of amplitude fluctuations. The case is considered for low altitudes, a narrow directional antenna, and a fairly smooth underlying surface. In such a case phase fluctuations can be neglected.

Mel'nichuk, Yu. V., and A. A. Chernikov. Backscatter matrix of centimeter waves by a wavy sea surface. IN: Trudy Tsentral'noy aerologicheskoy observatorii, no. 121, 1975, 58-70. (RZhF, 11/75, #11Zh147). (Translation)

Results are described of experimental studies on characteristics of backscatter matrices of centimeter waves from a wavy sea surface, at grazing angles below 3^{o}. It is shown that the square of moduli of matrix elements, σ_{ik} , correlates well with wind velocity, but only weakly with wave heights. At wind velocities above 2 m/sec, the relation $\sigma_{11}^{o} \geqslant \sigma_{22}^{o} > \sigma_{12}^{o} = \sigma_{21}^{o}$ (first subscript indicates polarization of emitted, second one indicates polarization of received centimeter waves) is always satisfied. At wind velocities of 1-2 m/sec this relation can become $\sigma_{11}^{o} > \sigma_{12}^{o} = \sigma_{21}^{o} > \sigma_{22}^{o}$. The dependence of σ_{ik} on grazing angle is established for various sea states and wind velocities. It is shown that the rate of decrease of $\sigma_{ik}^{o}(\Theta)$ depends on wind velocity. It is also established that σ_{ik}^{o} depends on azimuthal angle. The results are given of measurements of correlation functions for matrix elements. It is shown that diagonal elements a_{21} and a_{12} are best correlated. The correlation coefficients are 0.25 for a_{21} and a_{12} and less than 0.15 for a_{11}, a_{12} and a_{22}, a_{21}.

Mullamaa, Yu-A. R. Effect of macroroughness of scattering surfaces on the coefficients of brightness and reflection. IN: Oblachnost' i radiatsiya. Tartu, 1975, 191-211. (RZhGeofiz, 11/75, #11B159). (Translation)

Results are presented of a theoretical study on the effect of macroroughness of light-scattering surfaces on its coefficients of brightness and reflection (albedo). An approximate procedure for accounting for two-directional shading is developed. This procedure makes it possible to study optical characteristics of a wide range of macroroughness of light-scattering surfaces with steep slopes which cause rearrangement in angular distribution of brightness. In the plane perpendicular to plane of incidence, the brightness coefficient is practically independent of the zenith angle of incident light and of viewing angle, and it decreases monotonically with increase of roughness. The brightness coefficient also decreases in the direction of mirror reflection, while near surfaces having steep slopes the maximum brightness coefficient is attained in the direction of incident light during "backward" reflection. This fact is, for example, responsible for sharp peaks in phase functions of atmosphereless planets. The reflection coefficient of a gray scattering surface decreases with increase in macroroughness. For example, whereas the albedo of cumulus humilis is 0.7, the presence of a rough upper boundary plane reduces albedo by 18% for cumulus, and by 5% for stratus and stratocumulus.

Muro, E. L., G. V. Pavlova, and N.S. Fomin. Experimental correlation of wind speed, wind direction and wave state with energetic parameters of optical pulses reflected from a sea surface. IN: Trudy Tsentral'noy aerologicheskoy observatorii, no. 109, 1975, 101-106. (RZhGeofiz, 10/75, #10V109). (Translation)

The power of light pulses reflected from a sea surface at various incidence angles was measured. A pulsed flash lamp and parallel photodetector mounted on a revolving platform, at an altitude of 12 m and spacing of 30 cm, were used. The aperture of the source was 3^{o}, of the receiver 16^{o}. Wave heights were simultaneously measured by string wave recorder. Wind velocity and wind direction were measured as well. The measurements were carried out in the Caspian Sea in the region of Neftyanyye Kamni, 110 km or more off shore. It was found that characteristics of the reflected optical signal depend on wind velocity, wind direction, and wave state.

Nedovesov, A. N. Calculating the emission coefficient of a wavy sea surface in the microwave range. Morskiye gidrofizicheskiye issledovaniya, no. 2, 1975, 79-85. (RZhGeofiz, 2/76, #2V117). (Translation)

Formulas for calculating the emission coefficient of a wavy sea surface as a function of viewing angle are developed. The formulas are derived using the Kirchhoff approximation and assuming that the wavy sea surface is an ensemble of flat elementary surfaces and that emission does not depend on azimuth. The distribution function for slopes of the sea surface is derived on the basis of the Longuet-Higgins theoretical works and using a two-dimensional sea wave spectrum based on data of the State Planning, Design and Scientific Institute of Marine Transportation. Numerical calculations made for two stages of sea wave development show that emittance from a sea surface increases with decrease in relative steepness of waves; this increase is particularly noticeable in the case of large viewing angles.

Neklyudov, V. I., and S. D. Chuprov. Experimental study of amplitude fluctuation spectra of pulse tone signals, reflected from the ocean surface, at large Rayleigh numbers. Akusticheskiy zhurnal, no. 1, 1976, 81-85.

The cited acoustic experiment was conducted in the Atlantic Ocean in 1971. The source of pulse tone signals was placed at a depth of 200m, and a non-directional receiver at 350m. Radiation widths at the 0.7 level were 57, 36, 30, 60, and 17^{o} at frequencies of 1.0, 1.6, 2.0, 3.2, and 4.0kHz, respectively. Temperature stratification in the upper layer in the area of the experiment was unstable. Sound velocity varied from 1496-1498 m/sec over the 0-200m depth range, reaching 1500 m/sec at a depth of 350m. The experimental spectra

were compared to calculations for a simplified model. Spectra of amplitude fluctuations of pulse tone signals were calculated using N-P (Neuman-Pearson) and P-M (Pearson-Moskowitz) semiempirical wave spectra and formulas:

$$N(\tau)=\frac{\exp[\Phi^2 N_\xi(\tau)]-1}{\exp(\Phi^2)-1} \quad (1) \quad \text{and} \quad N_A(\tau)\cong N^2(\tau) \quad (2),$$

where $N_\xi(\tau)$ is normalized time autocorrelation for surface elevations, $\Phi=2k\sigma\sin\chi$ is the Rayleigh number; and $N_A(\tau)$ is the normalized autocorrelation for amplitude fluctuations of reflected signals $\Phi>>1$.

Examples of experimental and calculated spectra of scattered acoustic field and of amplitude fluctuations of acoustic signals are given in Figs. 1-3.

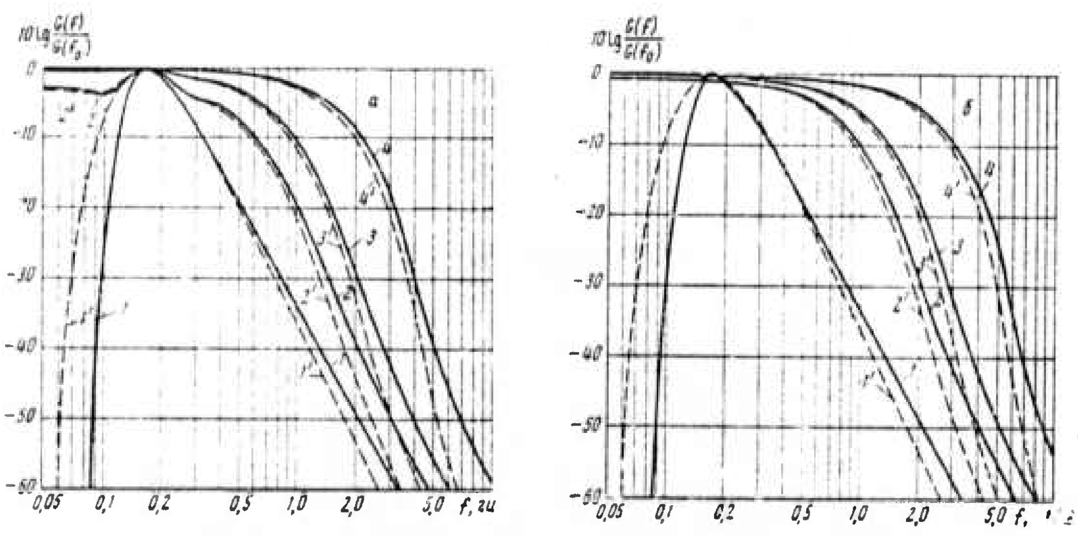


Fig. 1. Spectra of acoustic field scattered by the ocean surface (a), and of amplitude fluctuations of acoustic signals (b). Curves 2-4- calculations for Φ = 1.35, 2.06, and 4.45, respectively, using the P-M sea wave spectrum (curve 1); curves 2' -4' - the same, using N-P sea wave spectrum (curve 1').

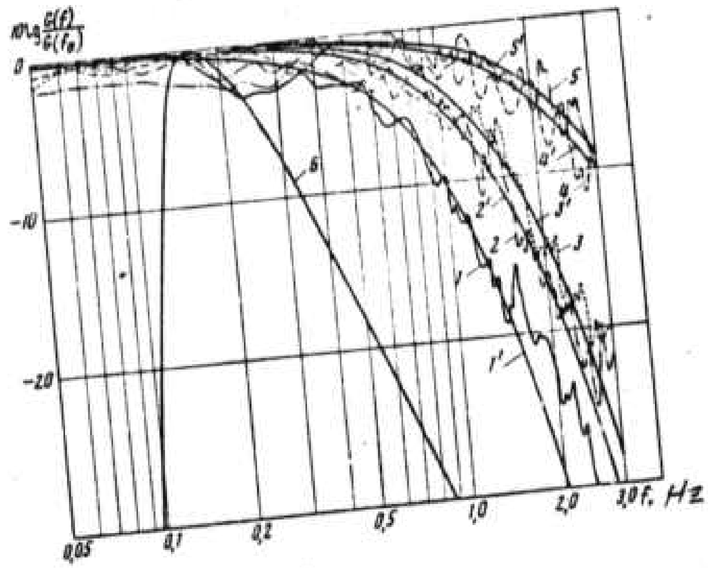


Fig. 2. Experimental (curves 1-5), and calculated (curves 1' -5') spectra of amplitude fluctuations of acoustic signal. Curves 1-5- signal frequencies = 1.0, 1.6, 2.0, 3.2, and 4 kHz, respectively; curves 1 -5 - calculations with use of P-M sea wave spectrum (curve 6) for Φ= 1.35, 2.06, 2.32, 4.0, and 4.45, respectively.

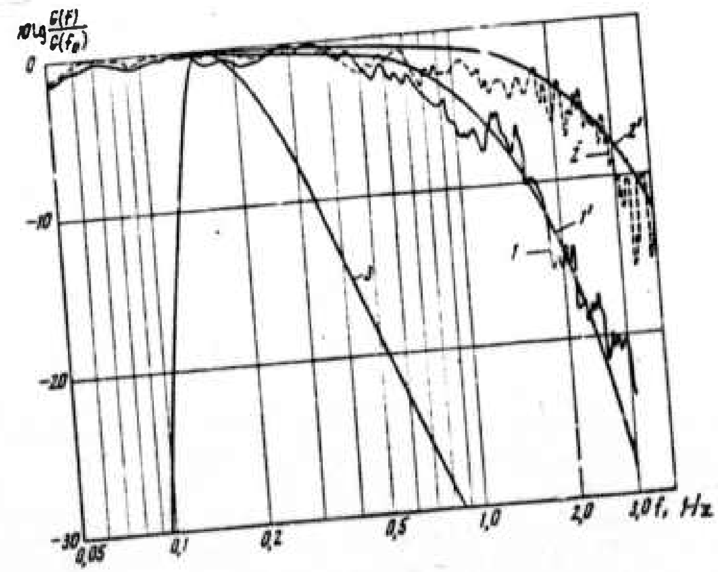


Fig. 3. Experimental (curves 1 and 2) and calculated (curves 1' and 2') spectra of amplitude fluctuations of acoustic signals. Curve 1- signal frequency 2 kHz, grazing angle 23°; curve 2- the same, grazing angle 55°; curves 1' and 2' - calculations with P-M wave spectrum for Φ= 2.32 and 4.74, respectively.

The authors conclude that a simplified model of sound scattering which assumes a point source, an unbounded scattering surface with gently-sloping relief, and small scattering angles, can be used in calculation of spectral characteristics of reflected acoustic signals, in the case when $\Phi >> 1$.

Nekontaktnyye metody izmereniya okeanograficheskikh parametrov (Remote methods of measurement of oceanographic parameters). Collection of papers presented at the All-Union seminar, Sevastopol', 4-7 Sept. 1973). Moskva, Gidrometeoizdat, 1975, 219 p. (RZhRadiot, 8/75, #8G18K). (Translation)

This seminar was organized by the State Oceanographic Institute, with twenty three institutions of various ministries and administrations participating. The papers presented at the seminar reflected the state-of-the-art in the field of active and passive remote methods of measurements of oceanographic parameters in the r-f, visible, and IR portions of the e-m spectrum, as well as in the range of ultrasonic waves.

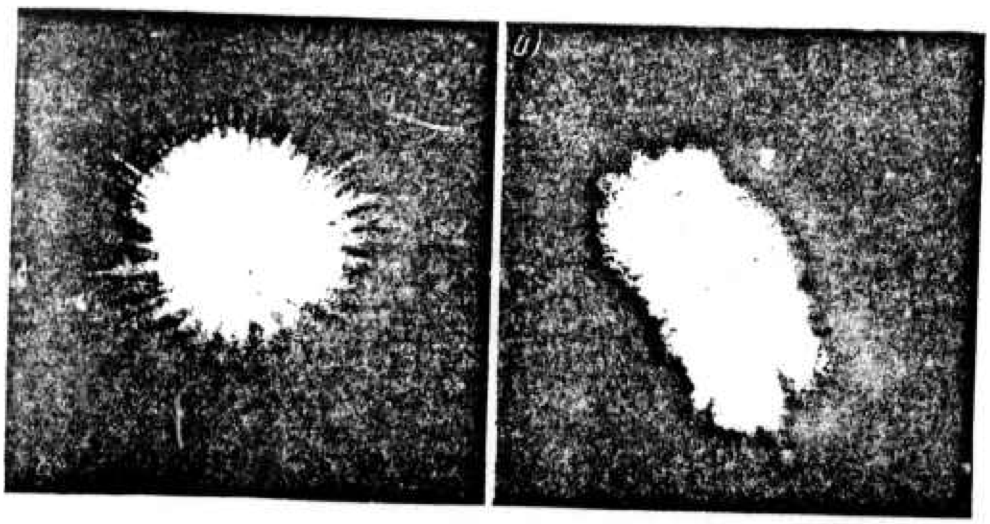
Rozenberg, A. D., I. Ye. Ostrovskiy, I. A. Leykin, and V. G. Ruskevich. Determining the energy-carrying component of a sea wave spectrum from phase characteristics of a radio signal scattered by the sea. IN: Nekontaktnyye metody izmereniya okeanograficheskikh parametrov. Moskva Gidrometeoizdat, 1975, 74-82. (RZhRadiot, 8/75, #8G28). (Translation)

A method is proposed for determination of orbital velocity, period, and propagation direction of energy-carrying components of sea waves from phase characteristics of a radio signal scattered by the sea. Preliminary laboratory and sea tests confirm the feasibility of the proposed method. An attachment to a standard Don ship radar which provides wave measurements was designed and fabricated. Applicability limits and accuracy of the method are analyzed; in particular the effect of ship roll on the measuring system needs consideration.

Shishkin, I. F. Target selection in the zone of (radar) reflection from ocean waves. Sudostroyeniye, no. 4, 1975, 45-46.

The problem of radar navigation in the zone of radar reflection from ocean waves (1850 - 5550 m) is discussed, and the addition of a target indicator circuit to a navigational radar is suggested as a possible solution of the problem. The principles of target classification can be accomplished either by means of a polarization-scan

indicator (Fig. 1), or by an analyzer of the pulse envelope (Fig. 2). The latter scheme requires both modernization of the antenna and an attachment for target range indication (Fig. 2, II) and analysis of low-frequency signals (Fig. 2, IV). The polarization plane of the antenna can be rotated by a synchronous motor in whose hollow rotor a rectangular waveguide is mounted. The target indication, with respect to the relative bearing, is made by antenna rotation.



(a) (b)

Figure 1. Photo of polarization-scan indicator (exposure 3 sec., rotation rate of polarization plane is 0.5 rev/sec).

a) 15 x 60 m^2 water surface irradiated at a grazing angle of 1^0, sea state 2;
b) same, but with a tugboat present.

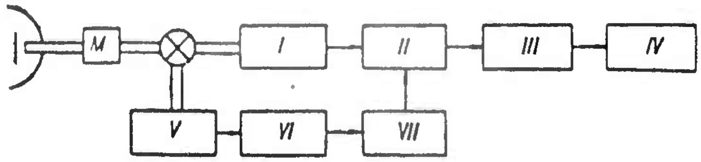


Figure 2. Simplified diagram of a target indication radar with a pulse envelope analyzer.

M - motor; I - receiver; II - coincidence stage;
III - demodulation circuit; IV - analyzer;
V - transmitter; VI - variable delay line;
VII - range-gate generator.

Shishkin, I. F. Study of wake in water areas.
Sudostroyeniye, no. 8, 1975, 45-48.

Radar observation of ship wakes is suggested as a possible solution to the problem of radar navigation in the zone of reflection from ocean waves. Radar visibility of various ship wakes is briefly described, and illustrations for various navigation conditions are included; Fig. 1 shows an example. The problem of abating the effect of space-time variability in the background reflections from sea waves is discussed and two possible solutions are suggested.

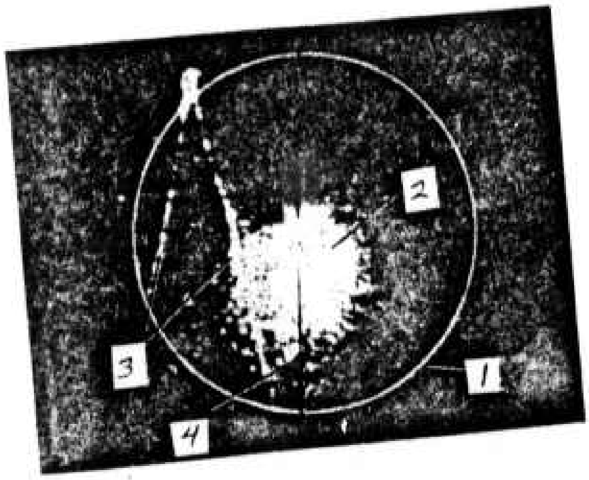


Fig. 1. PPI display of radar signal from bow waves of a 10,000 ton displacement tug.

1- range scale; 2- sea clutter; 3- bow waves; 4- mechanical reticle.

It is suggested that effects of space-time variability of the background reflections from sea waves can be reduced by adaptive automatic gain control or by a contrast reception method. Tabulated data are included on a contrast receiver type of ship radar, designed according to the requirement that the possibility of false alarm is independent of the intensity of background reflections.

Shupyatskiy, A. V. Relationship of polarization characteristics of a radar signal with various sea state parameters. IN: Nekontaktnyye metody izmereniya okeanograficheskikh parametrov. Moskva, Gidrometeoizdat, 1975, 115-121. (RZhRadiot, 9/75, #9G47). (Translation)

A description is given of instrumentation and techniques employed in the study of the relationship of polarization characteristics of a radar signal to the direction and height of wind-generated sea waves.

Voronin, V. A., S. F. Cherepantsev, and N. I. Kolyagin. On the problem of measuring sea wave lengths and crest length. IN: Prikladnaya akustika, no. 1, Taganrog, 1975, 36-39. (RZhGeofiz, 2/76, #2V41).

During scattering from a rough sea surface an acoustic signal is phase and amplitude modulated in accordance with the distribution of ordinates of the sea surface. If a reflected signal is passed through a high-frequency amplifier and linear detector, then an output

quasiharmonic signal is formed. The output signal is uniquely related to statistical characteristics of the sea surface. It is shown that the number of nulls at the output of the measuring channel is determined by the mean wavelength when the sea surface is scanned in the direction $\Theta = 0$, and by the mean crest length when the surface is scanned in the direction $\Theta = \pi/2$.

Voronin, V. A., N. I. Kolyagin, A. S. Sosunov, and S. F. Cherepantsev. Characteristics of a field scattered by a sea surface, allowing for displacement and velocity of the radar relative to the sea element. IN: Prikladnaya akustika, no. 1. Taganrog, 1975, 28-35. (RZhRadiot, 1/76, #1G33). (Translation)

An analysis is made of the effect of displacement and velocity of a radar relative to a sea element on the phase and frequency of the scattered signal. Results are described of calculation of Doppler shift under average hydrological conditions.

Zagorodnikov, A. A., and K. V. Chelyshev. Application of optical processing to remote measurements of sea waves. IN: Trudy Gosudarstvenogo okeanograficheskogo instituta, no. 117, 1973, 25-34. (RZhGeofiz, 2/74, #2V25). (Translation)

The use of optical methods in processing of radar and photo images of a sea surface makes it possible to calculate routinely the one- and two-dimensional spectra of sea waves. Basic principles of optical processing are discussed and techniques of one- and two-dimensional analysis are described. Examples of optical processing are given.

Zakharov, V. M., V. I. Pavlov, and V. Ye. Rokotvan. On the shape of optical pulses reflected from a sea surface. IN: Nekontaktnyye metody izmereniya okeanograficheskikh parametrov. Moskva, Gidrometeoizdat, 1975, 125-132. (RZhF, 9/75, #2D820). (Translation)

The problem of lidar measurements of sea wave parameters is considered. Expressions for the relationship between the shape of reflected pulses and geometric parameters of the sea surface are given. Three simplified cases are considered: sinusoidal wave and mirror reflection; diffuse reflection; and normal distributions of elevations and slopes of reflecting elements and mirror reflection.

Zhilko, Ye. O., and A. A. Zagorodnikov. Effect of foam and spray during stormy seas on the image quality of a side-look radar, based on results of the Bering experiment. IN: Sovetsko-Amerikanskiy eksperiment "Bering". Leningrad, Gidrometeoizdat, 1975, 80-91. (RZhGeofiz, 1/76, #1V94). (Translation)

The structure of sea waves is determined by spatial analysis of radar signals scattered by a sea surface. Pulsed signals were generated by a centimeter band side-look radar with a natural [sic] aperture. The largest distortions in radar image are caused by foam on the sea surface as well as spray above the sea surface. Radar images are sharpest when the sea surface is irradiated in the direction of, or opposite to, sea wave propagation. In such cases the wave relief is clearly visible whereas foam streaks are almost invisible. If radar images are obtained while transmitting across foam streaks, these stand out and obscure the sea wave profile. The presence of spray and foam has the effect of incoherent noise which conceals the useful signal. A theoretical analysis shows that foam-and spray-induced noise can be reduced considerably if a sufficiently large number of independent readings of reflected signal are used.

3. SOURCE ABBREVIATIONS

AiT	-	Avtomatika i telemekhanika
APP	-	Acta physica polonica
DAN ArmSSR	-	Akademiya nauk Armyanskoy SSR. Doklady
DAN AzSSR	-	Akademiya nauk Azerbaydzhanskoy SSR. Doklady
DAN BSSR	-	Akademiya nauk Belorusskoy SSR. Doklady
DAN SSSR	-	Akademiya nauk SSSR. Doklady
DAN TadSSR	-	Akademiya nauk Tadzhikskoy SSR. Doklady
DAN UkrSSR	-	Akademiya nauk Ukrayins'koyi RSR. Dopovidi
DAN UzbSSR	-	Akademiya nauk Uzbekskoy SSR. Doklady
DBAN	-	Bulgarska akademiya na naukite. Doklady
EOM	-	Elektronnaya obrabotka materialov
FAiO	-	Akademiya nauk SSSR. Izvestiya. Fizika atmosfery i okeana
FGiV	-	Fizika goreniya i vzryva
FiKhOM	-	Fizika i khimiya obrabotka materialov
F-KhMM	-	Fiziko-khimicheskaya mekhanika materialov
FMiM	-	Fizika metallov i metallovedeniye
FTP	-	Fizika i tekhnika poluprovodnikov
FTT	-	Fizika tverdogo tela
FZh	-	Fiziologicheskiy zhurnal
GiA	-	Geomagnetizm i aeronomiya
GiK	-	Geodeziya i kartografiya
IAN Arm	-	Akademiya nauk Armyanskoy SSR. Izvestiya. Fizika
IAN Az	-	Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk

IAN B	-	Akademiya nauk Belorusskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IAN Biol	-	Akademiya nauk SSSR. Izvestiya. Seriya biologicheskaya
IAN Energ	-	Akademiya nauk SSSR. Izvestiya. Energetika i transport
IAN Est	-	Akademiya nauk Estonskoy SSR. Izvestiya. Fizika, matematika
IAN Fiz	-	Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya
IAN Fizika zemli	-	Akademiya nauk SSSR. Izvestiya. Fizika zemli
IAN Kh	-	Akademiya nauk SSSR. Izvestiya. Seriya khimicheskaya
IAN Lat	-	Akademiya nauk Latviyskoy SSR. Izvestiya
IAN Met	-	Akademiya nauk SSSR. Izvestiya. Metally
IAN Mold	-	Akademiya nauk Moldavskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk
IAN SO SSSR	-	Akademiya nauk SSSR. Sibirskoye otdeleniye. Izvestiya
IAN Tadzh	-	Akademiya nauk Tadzhikskoy SSR. Izvestiya. Otdeleniye fiziko-matematicheskikh i geologo-khimicheskikh nauk
IAN TK	-	Akademiya nauk SSSR. Izvestiya. Tekhnicheskaya kibernetika
IAN Turk	-	Akademiya nauk Turkmenskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh, khimicheskikh, i geologicheskikh nauk
IAN Uzb	-	Akademiya nauk Uzbekskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IBAN	-	Bulgarska akademiya na naukite. Fizicheski institut. Izvestiya na fizicheskaya institut s ANEB
I-FZh	-	Inzhenerno-fizicheskiy zhurnal

IiR	-	Izobretatel' i ratsionalizator
ILEI	-	Leningradskiy elektrotekhnicheskiy institut. Izvestiya
IT	-	Izmeritel'naya tekhnika
IVUZ Avia	-	Izvestiya vysshikh uchebnykh zavedeniy. Aviatsionnaya tekhnika
IVUZ Cher	-	Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya
IVUZ Energ	-	Izvestiya vysshikh uchebnykh zavedeniy. Energetika
IVUZ Fiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Fizika
IVUZ Geod	-	Izvestiya vysshikh uchebnykh zavedeniy. Geodeziya i aerofotos'yemka
IVUZ Geol	-	Izvestiya vysshikh uchebnykh zaveniy. Geologiya i razvedka
IVUZ Gorn	-	Izvestiya vysshikh uchebnykh zavedeniy. Gornyy zhurnal
IVUZ Mash	-	Izvestiya vysshikh uchebnykh zavedeniy. Mashinostroyeniye
IVUZ Priboro	-	Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye
IVUZ Radioelektr	-	Izvestiya vysshikh uchebnykh zavedeniy. Radioelektronika
IVUZ Radiofiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika
IVUZ Stroi	-	Izvestiya vysshikh uchebnykh zavedeniy. Stroitel'stvo i arkhitektura
KhVE	-	Khimiya vysokikh energiy
KiK	-	Kinetika i kataliz
KL	-	Knizhnaya letopis'
Kristall	-	Kristallografiya
KSpF	-	Kratkiye soobshcheniya po fizike

LZhS	-	Letopis' zhurnal'nykh statey
MiTOM	-	Metallovedeniye i termicheskaya obrabotka materialov
MP	-	Mekhanika polimerov
MTT	-	Akademiya nauk SSSR. Izvestiya. Mekhanika tverdogo tela
MZhiG	-	Akademiya nauk SSSR. Izvestiya. Mekhanika zhidkosti i gaza
NK	-	Novyye knigi
NM	-	Akademiya nauk SSSR. Izvestiya. Neorganicheskiye materialy
NTO SSSR	-	Nauchno-tekhnicheskiye obshchestva SSSR
OiS	-	Optika i spektroskopiya
OMP	-	Optiko-mekhanicheskaya promyshlennost'
Otkr izobr	-	Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki
PF	-	Postepy fizyki
Phys abs	-	Physics abstracts
PM	-	Prikladnaya mekhanika
PMM	-	Prikladnaya matematika i mekhanika
PSS	-	Physica status solidi
PSU	-	Pribory i sistemy upravleniya
PTE	-	Pribory i tekhnika eksperimenta
Radiotekh	-	Radiotekhnika
RiE	-	Radiotekhnika i elektronika
RZhAvtom	-	Referativnyy zhurnal. Avtomatika, telemekhanika i vychislitel'naya tekhnika
RZhElektr	-	Referativnyy zhurnal. Elektronika i yeye primeneniye

RZhF	-	Referativnyy zhurnal. Fizika
RZhFoto	-	Referativnyy zhurnal, Fotokinotekhnika
RZhGeod	-	Referativnyy zhurnal. Geodeziya i aeros"-yemka
RZhGeofiz	-	Referativnyy zhurnal. Geofizika
RZhInf	-	Referativnyy zhurnal. Informatics
RZhKh	-	Referativnyy zhurnal. Khimiya
RZhMekh	-	Referativnyy zhurnal. Mekhanika
RZhMetal	-	Referativnyy zhurnal. Metallurgiya
RZhMetrolog	-	Referativnyy zhurnal. Metrologiya i izmeritel'naya tekhnika
RZhRadiot	-	Referativnyy zhurnal. Radiotekhnika
SovSciRev	-	Soviet science review
TiEKh	-	Teoreticheskaya i eksperimental'naya khimiya
TKiT	-	Tekhnika kino i televideniya
TMF	-	Teoreticheskaya i matematicheskaya fizika
TVT	-	Teplofizika vysokikh temperatur
UFN	-	Uspekhi fizicheskikh nauk
UFZh	-	Ukrainskiy fizicheskiy zhurnal
UMS	-	Ustalost' metallov i splavov
UNF	-	Uspekhi nauchnoy fotografii
VAN	-	Akademiya nauk SSSR. Vestnik
VAN BSSR	-	Akademiya nauk Belorusskoy SSR. Vestnik
VAN KazSSR	-	Akademiya nauk Kazakhskoy SSR. Vestnik
VBU	-	Belorusskiy universitet. Vestnik
VNDKh SSSR	-	VNDKh SSSR. Informatsionnyy byulleten'
VLU	-	Leningradskiy universitet. Vestnik. Fizika, khimiya
VMU	-	Moskovskiy universitet. Vestnik. Seriya fizika, astonomiya

ZhETF	- Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhETF P	- Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhFKh	- Zhurnal fizicheskoy khimii
ZhNiPFiK	- Zhurnal nauchnoy i prikladnoy fotografii i kinematografii
ZhNKh	- Zhurnal neorganicheskoy khimii
ZhPK	- Zhurnal prikladnoy khimii
ZhPMTF	- Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki
ZhPS	- Zhurnal prikladnoy spektroskopii
ZhTF	- Zhurnal tekhnicheskoy fiziki
ZhTFP	- Pis'ma v Zhurnal tekhnicheskoy fiziki.
ZhVMMF	- Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki
ZL	- Zavodskaya laboratoriya

4. AUTHOR INDEX